

Acute Myocardial Infarction across the Continuum of Care: Examining Care, Costs, Outcomes  
and Equity

Author: Deborah Cohen

Supervisor: Dr. Douglas G. Manuel

Co-supervisor: Dr. Peter Tugwell

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University of Ottawa

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*To my family:*

*Thank you to my husband Michael for his unwavering love and support every step of the way. From our endless discussions about statistics and healthcare - to just knowing when 'not' to talk about it. You are my rock.*

*Thank you to my children Zach and Beth who helped me put it all in perspective. I am so proud of you both.*

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## Preface

This thesis dissertation received ethics approval from the Ottawa Hospital Ethics Review Board, protocol number 2011741-01H. The author Deborah Cohen conducted all literature reviews, statistical data analysis, and writing of each manuscript (included here as chapters 2-5). I would like to thank my thesis supervisor Doug Manuel who provided general guidance and mentoring on the complete thesis, assisted in establishing research projects, provided content and statistical knowledge, and reviewed the work. Thanks also to my thesis co-supervisor Peter Tugwell and thesis committee members Claudia Sanmartin and Tim Ramsay who provided content and statistical guidance, and reviewed the work. These individuals were co-authors on each of the manuscripts submitted for publication.

Acute Myocardial Infarction across the Continuum of Care: Examining Care, Costs, Outcomes  
and Equity

Abstract

Among the manifestations of cardiovascular disease, acute myocardial infarction (AMI) holds a place of prominence in Canadian health policy. AMI is the number one cause of death for heart disease in Canada and costs the system over 500 million dollars in hospital stays annually.

Because of the significant population-wide health and economic impact of AMI, disease management strategies that maximize health outcomes and minimize AMI's overall burden to society are key areas of health policy research in Canada.

For decades policy makers in healthcare have pointed to challenges with system fragmentation and the role of the continuum of care for diseases such as AMI, to optimize patient outcomes within limited healthcare budgets. Despite these concerns, there is a surprising lack of research focused on the care continuum for AMI. Instead much of the existing research continues to focus on AMI care, cost, outcomes and equity within a particular sector of care. Consequently, there remains a lack of baseline knowledge about patient care trajectories for AMI starting from preventive primary care, to treatment received in acute care, to corresponding patient outcomes.

To address this gap in the knowledge base, this thesis dissertation takes a broad system view of AMI across the continuum of care, and examines the system with a patient-centric perspective. This research examines the patient care trajectory and puts forward baseline information on AMI care, cost, outcomes and equity that can be used in future research and policy initiatives to advance the continuum of care approach for AMI in Canada.

## Chapter 1: Acute Myocardial Infarction across the Continuum of Care: Examining Care, Costs, Outcomes and Equity

Cardiovascular disease (CVD) represents the leading cause of death in the world, accounting for approximately one-third of all deaths globally (Deaton et al. 2011; Tu et al., 2009). In Canada, CVD claims more than 49,000 lives annually, accounting for more than 30% of all deaths and costing the Canadian economy an estimated 22 billion dollars per year (Conference Board of Canada, 2010; Manuel et al., 2003; Smolderen et al., 2010). Among the manifestations of CVD, acute myocardial infarction (AMI) holds a place of prominence in Canadian health policy. In the Canadian context, AMI has a mortality rate at approximately 75 per 100,000 (Tu et al., 2009), and has been shown to be a significant financial burden to society. According to the Canadian Institute for Health Information (CIHI), AMI represents the ‘most expensive’ health condition for acute-care hospitalizations in Canada - costing over 500 million dollars in hospital stays annually (CIHI, 2008a), and requiring over 50,000 patient hospitalizations per year (Kolansky, 2009; Tu et al., 2009). Because of the significant population-wide health and economic impact of AMI, disease management strategies that maximize health outcomes and minimize AMI’s burden to society are key areas of Canadian health policy research (Tu & Cameron, 2002).

Canada has seen a steady decline in AMI mortality rates over the last several decades, with the age-sex standardized rate of death for AMI decreasing by almost 40% between the years of 1994 to 2004 (Tu et al., 2009). Despite this drop, AMI remains the number one cause of death for heart disease in Canada (Tu et al., 2003). Research has attributed much of the downward trend in AMI mortality to two major areas of investment; prevention and disease management protocols within the healthcare system, and broader social programming to address population-wide improvements in major risk factors for heart disease (Critchely & Capewell, 2003; Ford & Capewell, 2007; Ford et al., 2007; Stampfer et al., 2000; Manuel et al., 2003, James et al., 2007). The substantial contribution of the healthcare system in the declining trends in AMI mortality is particularly noteworthy. It is estimated that investments over the last several decades in AMI preventive care, diagnostic services and medical treatment account for 50% of the declines in AMI mortality at the population level (Ford & Capewell, 2007; Unal et al., 2005). This research points to the critical role of healthcare in addressing AMI and identifies AMI healthcare research as a key investment to ensure continued reductions in the disease burden in Canada.

As Canada's healthcare system continues to serve as a partner in addressing the disease burden for AMI, the careful balance between prevention, treatment and disease management is played out along the continuum of care. However like most systems, Canada's healthcare system is fragmented (Anderson & Newman, 1974; Bergman et al., 1997; Deber, 2003; Kodner, 2009). As healthcare becomes more specialized and patients with chronic disease are seen by an increasing number of care providers, there is a growing concern about the fragmentation of care (Wagner, 2005). The fragmented nature of care can create access challenges for AMI patients as they make transitions between the primary care sector, the acute care sector and beyond (van Walraven et al., 2004a). In addition to lower patient satisfaction and increased risk of medical error (Haggerty et al., 2003; Maizes et al., 2009; Parry et al., 2003), fragmentation along the care continuum has also been shown to reduce overall efficiency in the system, driving healthcare costs up and optimal health outcomes down (Haggerty et al., 2003; MacAdam, 2008; Bodenheimer, 2008; Hwang, et al., 2013).

For decades policy makers in Canadian healthcare have pointed to challenges with system fragmentation and the role of the continuum of care in improving health system performance and patient outcomes (Bergman et al., 1997; Hoffmarcher et al., 2007; MacAdam, 2008). However despite policy concerns related to the care continuum for diseases such as AMI, which require contributions from multiple sectors to optimize patient outcomes, there is a surprising lack of research that has explored AMI beyond a particular sector of care. A considerable body of research in Canada has examined services for AMI within the acute care sector (Alter et al., 1999; Elbarouni et al., 2012; Ko et al., 2005; Rawson et al., 2012; Rosval et al., 2008; Tu et al., 2003), and within the primary care sector (Al-Omaran et al., 2008; Grover et al., 2000; Jackevicious et al., 2008). However despite evidence acknowledging the contributions of multiple sectors, AMI research has generally failed to take a broader view across the care continuum (McKee & Nolte, 2009).

Unlike traditional healthcare research, continuum of care research must be person-centric, recognizing patient transitions between sectors and interactions with different clinicians in order to achieve optimal prevention, diagnosis, treatment, and outcomes (Kodner & Spreuwenberg, 2002). Without this baseline knowledge, policy-makers will continue to struggle to optimize the system to ensure smooth transitions between sectors and to implement effective integrated care

strategies (Barr et al., 2003). To address this gap in the knowledge base, this thesis dissertation takes a broad system view of AMI across the continuum of care, and examines the system with patient-centric system perspective, rather than a conventional service-centric perspective (Haggerty et al., 2003). The research presented here puts forward baseline information that can be used in future research and policy initiatives to advance the continuum of care approach for AMI in Canada.

To guide this inquiry of AMI across the continuum of care, this thesis is informed by an overarching health system performance framework that is grounded in an integrative approach to care. The Institute for Healthcare Improvement's (IHI) Triple Aim Framework (IHI, 2008), has been increasingly recognized across Canada and the United States for its innovative vision for integrative health system reform since its launch in 2007. The power of the framework lies in its simplicity as it identifies three elementary pillars of investment for system performance optimization - improving the quality of care; improving patient and population health outcomes; and reducing the per capita cost of healthcare. Further, this framework acknowledges that each area of investment must be built upon principles of equity, to ensure that health services and spending are distributed equitably across the population (Berwick, 2008). This visionary approach to healthcare in which health system costs and healthcare quality must be balanced against the needs of the population and improved health outcomes for all, articulates four fundamental system goals – care, costs, outcomes and equity – which must be pursued simultaneously to optimize health system performance. According to the Institute, these four goals must be measured regularly to monitor system progress and inform future action (IHI, 2008).

To build a baseline of knowledge for AMI across the continuum of care, the Triple Aim's four fundamental system goals - costs, care, outcomes and equity – are used to establish the key objectives for this body of work. It must be acknowledged that these four goals represent an enormous area of inquiry which cannot be completely studied within the confines of a single thesis dissertation. Instead, the present work attempts to fill knowledge gaps in these four areas and to point to future work that can further inform the debate. These objectives will be explored through the development of three distinct research studies presented in the following chapters of this dissertation.

## THESIS OBJECTIVES

The thesis objectives are as follows:

- 1) Care: Well defined clinical care trajectories have been established for AMI in Canada. These care processes have been published in numerous clinical practice guidelines related to the diagnosis, prevention, treatment and disease management of AMI in order to optimize health outcomes for patients and the population at large (Anderson et al., 2013; Leiter et al., 2011; CDA, 2008; O’Gara et al., 2013; Tobe et al., 2011; Daskalopoulou et al., 2012). However, the majority of research for AMI has focused on services utilized at time of, or the time following the infarction event, thereby leading to a gap in the literature about the role of primary care in the diagnosis and prevention of the disease. This is somewhat surprising given the preventable nature of heart disease and the fact that many AMI risk factors are amenable to primary care intervention (Franklin & Cushman, 2011; Harkins et al., 2010; Grover et al., 2000; Weintraub et al., 2011). The first objective of the thesis was to explore the role of primary and secondary prevention for AMI in primary care prior to a patient’s first AMI event, in order to examine the utilization of specific services as per practice guidelines.
- 2) Cost: To date, research on the cost and cost drivers of patient’s with AMI have been measured only within the acute care sector, and typically only for the patient’s first AMI episode of care (Azoulay et al., 2003; CIHI, 2008a; Krumholz et al., 1998). As a result, total baseline costs for AMI patients across the care continuum have not yet been determined. This lack of baseline costing data creates a gap in the knowledge base for measuring and monitoring the ‘costing’ goal for AMI within the Triple Aim. The second thesis objective was to examine direct healthcare costs and cost drivers for AMI patients along the continuum of care, from preventive primary care, to treatment in acute care, to disease management following the AMI event.
- 3) Equity: The universal nature of the Canada’s healthcare system ensures that financial barriers to physician and hospital services are mitigated via progressive tax-based financing (Badgley & Wolfe, 1992; Hanratty et al., 2007). However in spite of the universal model in which financial access barriers to care should not be commonplace, Canadian research has demonstrated patterns of socioeconomic inequity in service use for AMI within the acute care sector (Alter et al., 1999; Perelman et al., 2009; Pilote et al., 2003). To date however, there exists a paucity of research that

has examined equitable access to care for AMI patients across the care continuum. Given that AMI clinical care trajectories require services across a continuum of sectors, it is possible that inequitable access to care in one sector could lead to inequitable access to care in subsequent phases of care. The third objective of the thesis was to explore socio-economic differences in healthcare utilization for AMI patients across the care trajectory.

4) Outcomes: One of the core interests of the Triple Aim Framework is the notion of value for money in healthcare (Cutler, 2006; Gov Saskatchewan, 2012; McCarthy & Klein, 2010). In Canada and around the world policy makers continue to struggle to answer the question ‘Does more expensive care produce better patient outcomes?’ (Blomqvist & Busby, 2012; Culter et al., 2006; Hollander et al., 2009). Patient level research in the United States and Europe has demonstrated that higher spending produces improved patient outcomes for AMI (McClellan et al., 1994; Schreyogg & Stargardt, 2010; Stargardt et al., 2013), however research conducted in Canada’s universal health system context is rather limited. The final objective of this thesis was to examine the relationship between AMI health spending and AMI survival within the Canadian universal healthcare context.

## LITERATURE REVIEW

### Understanding AMI

CVD, also known as heart disease and stroke, represents a group of conditions that affect the structure and function of the heart and associated vessels (Heart & Stroke, 2014). Causes of CVD are diverse but many are associated with the development of atherosclerosis, a narrowing or blockage of myocardial blood vessels causing a loss in vessel elasticity and a reduction of oxygenated blood supply to the heart. The plaque formation in atherosclerosis can have multiple consequences giving rise to other heart conditions such as acute coronary artery disease, stroke, angina, and AMI (Braunwald, 2012). AMI occurs when a blockage of, or significant narrowing to, one or more of the coronary arteries exceeds a critical threshold and results in myocardial injury and or cellular necrosis. If the blockage is not resolved quickly, sufficient necrotic damage can diminish or halt cardiac function and potentially lead to death (Braunwald, 2012).

Two types of myocardial infarction, non-ST elevation myocardial infarct (non-STEMI) and ST elevation myocardial infarct (STEMI) make up two basic classes of AMI. This infarct classification type can be used to approximate levels of AMI severity, as determined by the ST segment elevation in electrocardiogram (ECG) testing (McManus et al., 2011). In a STEMI event, the coronary artery is subject to a complete occlusion, creating an ST segment elevation in the ECG results, indicating that a relatively large portion of the heart muscle has been damaged. In a non-STEMI event, the coronary artery becomes only partially occluded. In these cases, ST elevation is not registered in the ECG results, generally indicating less damage to the heart muscle overall (Braunwald, 2012). While other clinical level data such as serum enzymes and cardiac biomarkers of myocardial necrosis are reviewed to assess myocardial infarct status in the clinical context (Gibler et al., 1990), the STEMI versus non-STEMI classification is regularly coded and available within hospital administrative discharge data. As a result, this broad classification is used to differentiate infarct types within the epidemiological literature.

### Patient Outcomes

Among the patients experiencing STEMI and non-STEMI AMI, research has generally found 30-day mortality outcomes to range between 3 and 5% (Roe et al., 2010) and a one-year mortality of between 15 and 20% (Krumholz et al., 2001; Tu et al., 2001; Schiele, 2005). Short

term mortality has been found to be lower in patients with non-STEMI infarcts (2-4%) compared to STEMI infarcts (3-8%), with results varying based on in-hospital medical procedures applied (Roe et al., 2010; Canon et al., 2000; Stone et al., 2002). In contrast, longer term mortality outcomes (one year and longer) have even been found to be similar among STEMI and non-STEMI patients, with some research even finding that non-STEMI patients have poorer long term survival than STEMI patients (Furman et al., 2001; Behar et al., 1996; Yan et al., 2004).

Patient outcomes for AMI have implications that extend well beyond basic survival however. Besides death, other negative patient outcomes can include increased risk of angina, stroke, heart failure and recurrent AMI (Breiger et al., 2009; Maddox et al., 2008), as well as increased risk of depression and anxiety, reduced quality of life, and restrictions in daily activities (Dickens et al., 2006; de Jonge et al., 2006). Taken together, this research points to the substantial disease burden of AMI for patients and also for the healthcare system, in which follow-up treatments for co-morbid conditions and new health issues arising from AMI must be addressed.

#### The Population Affected

AMI affects a broad range of individuals within the population. Tu et al. (2009) reported an age-sex standardized rate of hospital admissions for AMI at 206 per 100,000 in the Canadian population in 2004. The risk of AMI rises with increasing age, however the disease process itself often begins early in life and is influenced over decades by behavioural, social-ecological, and environmental factors (Berra et al., 2011). Seniors are most affected by the direct manifestations of AMI with the median age of AMI occurring at approximately 70 years of age, and the risk of AMI continuing to rise for every additional year (Tu et al., 2009). Research has demonstrated a ten-fold greater incidence of AMI among those 65 and over as compared to those 35 to 44, and a persistently higher case fatality rate (Roger, 2009; Yazdanyar & Newman, 2009). As a result, much of the AMI health and outcomes literature has been targeted on the over-65 segment of the population (Carstairs & Keon, 2009; Krumholz et al., 1998; Yazdanyar & Newman, 2009). However, a body of research has also focused on AMI in younger adults because AMI risk factors are known to accumulate across the life course, and opportunities for prevention may be most apparent among those in younger generations (Akosash et al., 2003).

Much of the existing AMI research has reported higher rates of cardiac procedures in men as compared to women, with AMI hospitalizations in men accounting for approximately two-thirds of all encounters (Tu et al., 2009). However differences in disease burden by sex are often diminished or eliminated when age is adjusted for (Fransoo et al., 2010; Tu et al., 2009). In general, differences in AMI rates between males and females tend to be most pronounced at younger ages because of the protective effects of estrogen in women below the age of 50. However this sex difference in AMI rates is reduced in older ages due to the biological and hormonal modifications of menopause (Fioretti et al., 2000). Some research has demonstrated a higher short-term mortality rate after AMI in females in younger age groups which have been attributed to less aggressive treatment approaches and the corresponding presence of other attendant co-morbidities (Anderson & Pepine, 2007; Izadnegahdar et al., 2013). These sex differences are attenuated when comorbid illness and key AMI medical and pharmaceutical treatments are adjusted for (Vaccinaro et al., 1999; Vaccarino et al., 2009). These findings, which emphasize the substantial disease burden for women are noteworthy, given that historically heart disease has been considered to be a problem predominantly in men.

### Risk Factors

Since the earliest Framingham heart studies in the 1960s and 70s, risk factors for AMI have been well studied (Kannel et al., 1978; Kannel et al., 1979; Tanusepturo et al., 2003). Risk factors for AMI can be conceived of as both proximal (those risk factors that present an immediate vulnerability for a particular condition or event) as well as distal (broader social ecological factors that accumulate over time to place an individual at risk of an event) (Kreiger, 2008). While much of the medical literature has focused on proximal risk factors for AMI related to pre-cursive medical conditions, co-morbid illness and individual level behaviours, population health research has also identified a broader set of social determinants of health that have implications for AMI and poorer health in general.

Proximal risk factors for AMI typically include hypertension, hyperlipidemia, diabetes mellitus, obesity, physical inactivity and smoking (Body et al., 2008; Jaglal et al., 1999; Yusuf et al., 2004). While some of these risk factors have significant behavioural components, most of these risk factors have been shown to be preventable through targeted efforts in primary care (Harkins et al., 2010; Grover et al., 2000; Weintraub et al., 2011). Each of these risk factors increases the

risk of development of heart disease individually, however research has demonstrated that the risk of the development of heart disease is more dependent upon the cumulative effects of multiple factors over time (Anderson et al., 1991; NVDPA, 2009; Yusuf et al., 2004). These findings point to the critical role of primary care in diagnosing and addressing the set of proximal risk factors through primary and secondary prevention so that AMI onset can be avoided in higher risk groups.

Beyond the proximal medical conditions, a number of other distal social and environmental factors have also been shown to contribute to the risk of AMI (Lynch et al., 1996; Mensah et al., 2005). These underlying determinants – the ‘causes of the causes’ – reflect the major forces of social and economic drivers of poor health in general society and include factors such as racism, low levels of education, low levels of control and corresponding stress, and poverty (Joffe, 1996; Marmot, 2005). Poor socio-economic status (SES) in particular, which can reflect both social and material aspects of an individual’s societal status, has been identified as key underlying cause of heart disease (Adler & Newman, 2002; CIHI, 2008b; Marmot, 2010). A 2010 CIHI study found a 37% difference in the prevalence rate of AMI between Canada’s highest and lowest income neighbourhoods (at 255 per 100,000 in least affluent neighbourhoods compared to 186 per 100,000 most affluent neighbourhoods) (CIHI, 2010). Research has also found that low SES negatively influences post-AMI survival. Low SES patients continue to have higher rates of mortality compared to high SES patients, even when other proximal risk factors have been controlled for (Alter et al., 1999; Blais et al., 2013; Chang et al., 2007). While the healthcare system may have less control and influence over these broad social-ecological factors, it is important for clinicians to recognize these distal AMI risk factors to ensure equitable access to quality healthcare for all (Marmot, 2010).

### Continuum of Care for AMI

Despite substantial advances in the development of standardized health administrative databases across primary, secondary and tertiary sectors of care in the last several decades (CIHI, 2013b), research on the continuum of care has not been yet well developed. This lagged development of the continuum of care research may be due in part to a lack of standardized basic conceptual terminology to guide this emerging field of scholarly inquiry (Kodner & Spreeuwenberg, 2002).

Definitions for the continuum of care have taken many forms depending upon the emphasis of the discipline, the intended short and long term goals, and perceptions about the most critical actor involved in its pursuit (Kodner & Spreeuwenberg, 2002). Elements of the continuum of care paradigm are embedded in a terminological myriad including terms such as integrated care, patient and person-centred care, continuity of care, coordinated care, and patient pathways (Menec et al., 2005; Kodner & Spreeuwenberg, 2002; Maizes et al., 2009; Matheson & Neuwelt, 2012; Wagner et al., 2005), all of which emphasize the concept of continuity but each through its own unique lens.

In recognition of the poorly standardized conceptual terminology for continuum of care research, Haggerty and colleagues (2003) conducted a multidisciplinary review of the literature as well as Canadian wide workshops on the issue of the continuum of care. This systematic review found that despite the diversity in approaches to the care continuum, research across all disciplines was underpinned by two core elements. According to this research group, “Continuity can only exist as an aspect of care that is experienced *by an individual*, and that is *received over time*” (CHSRF, 2002, p3.). These two fundamental elements of the continuum of care - person and time - distinguish continuum of care research from the contemporary health services research in which the focus has traditionally been on specific services or sectors of care. Based on this key finding, the elements of ‘person’ and ‘time’ will be adopted in this thesis dissertation to guide the research and ensure that emphasis is placed on processes related to patients rather than summary measures of service use within sectors.

### Triple AIM as an Integrative function

The Triple Aim Framework suggests that four fundamental components care, cost, outcomes and equity must not be pursued independently, but rather through an integrative function in order to achieve balance across all four components simultaneously (Berwick et al., 2008). Pursuing these components together allows healthcare organizations to identify and solve care coordination issues, and to direct resources to programs and strategies that have the biggest impact on health outcomes. The IHI suggests that if the components are not pursued simultaneously, health organizations may risk improving in one area and the expense of another (IHI, 2008). For example, organizations focused exclusively on quality may improve care and health outcomes at the expense of cost, while organizations focused exclusively on cost, may

reduce expenditures at the expense of equitable access to services and quality care (McCarthy & Klein, 2010).

In order to assist organizations in pursuing the Triple Aim, the IHI points to the importance of good baseline information on all four components and regular monitoring to ensure a balanced success is achieved (IHI, 2008). In the Canadian context, many health organizations are taking on the Triple Aim framework (Dentzer, 2013; Gov of Sask, 2012; Huynh & Cohen, 2013), but gaps in the knowledge base related to quality, cost, outcomes and equity across the care continuum may create challenges in monitoring balanced success. The following section outlines a number of gaps in the AMI continuum of care literature related to the four components of the Triple Aim Framework.

## Care

Among the four areas of investment within the Triple Aim Framework, the Care component has been most well studied for AMI. In particular, AMI research has examined the therapeutic effectiveness and utilization of specific diagnostic and treatment technologies for AMI. These technologies are typically performed in acute care once the AMI event has occurred.

Over the last thirty years, research has demonstrated that rapid diagnosis and stratification of AMI severity are critical to identify patients for whom early clinical interventions can improve outcomes (Riera, 2003). Correspondingly utilization rates of cardiac diagnostic techniques such as coronary angiography, echocardiography, electrocardiography (ECG), and stress testing delivered in hospital settings have all increased over the last several decades (Alter et al., 2006). In particular coronary angiography, an x-ray of the coronary arteries, is utilized regularly as a tool for early evaluation of coronary artery disease to detect the location and severity of the arterial blockage, to guide medical and pharmaceutical treatments following AMI (van der Werf et al., 2003).

In addition to diagnostic technologies, significant advances in treatment approaches have also been made, including percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG) surgery. PCI is a relatively non-invasive procedure used to open the narrowed or blocked heart arteries in order to restore blood supply to the heart, and has been shown to improve AMI STEMI patient outcomes and reduce heart damage caused by the AMI

(Braunwald, 2012). Utilization rates for PCI have almost tripled over the last two decades in Ontario, Canada (from 0.5 per 1000 to 1.4 per 1000 population) (Alter et al., 2006). In contrast, the more invasive CABG procedure, a surgical technique in which a healthy artery is grafted to the heart in order to bypass the block coronary artery, is used for a sub-group of patients with complex lesions and/or severe coronary heart disease. While patient outcomes have been found to be similar for both types of interventions (Maurice et al., 2014), utilization rates for PCI generally exceed CABG surgeries by approximately 60% (186 PCI procedures per 100,000 compared with 70 CABG procedures per 100,000 in 2005 at the national level (Hassan et al., 2010)). This is largely due to the broader range of patient risk that can be accommodated by PCI, the increasingly complex blockages that can be addressed, and patient/physician preferences for less invasive procedures to address damage associated with AMI (Hassan et al., 2010).

In addition to advances in medical technologies, pharmaceutical approaches to treat and manage issues associated with AMI have also proliferated over the last several decades. Utilization rates in drug classes such as statins, beta blockers, calcium channel blockers and ace inhibitors, have increased dramatically to prevent, treat and manage the complications of heart disease (Jackevicious et al., 2008). According to clinical practice guidelines, all patients should be offered acetacylic acid, a beta blocker, an ace-inhibitor and a statin following AMI (Antman et al., 2004; Skinner et al., 2007; O’Gara et al., 2013) as a secondary prevention strategy. In particular, the cardio-protective effect of statins have been noted both in primary and secondary prevention of AMI to lower cholesterol levels that have reached a critical threshold (Taylor et al., 2013; Ward et al., 2007). Practice guidelines suggest that statins should be prescribed for any patient regardless of previous AMI history with a low-density lipoprotein cholesterol level of 190 mg/dl or higher (Stone et al., 2013).

AMI preventive care strategies, largely provided within primary care, have also undergone significant advances over the last several decades (Taylor et al., 2013). These preventive services most typically address common AMI pre-cursive risk factors such as hypertension, hyperlipidemia and diabetes. Many of the pharmaceutical therapies listed above have applications both in primary and secondary prevention of heart disease (Franklin & Cushman, 2011; Taylor et al., 2013). Critical diagnostic tests including lipid and glucose testing, ECG,

echocardiogram and stress testing are also performed within the primary care setting to detect pre-cursive risk factors for at-risk patients. Each of these diagnostic tests are considered routine, non-invasive, primary and secondary preventive services for AMI and are included in a number of clinical practice guidelines for the prevention of cardiovascular disease (Anderson et al., 2013; CDA, 2008; Daskopoulou et al., 2012; Lieter et al., 2009; Tobe et al., 2011). For lipid and glucose testing in particular, the clinical risk profile required to trigger a diagnostic test is quite broad. Clinical practice guidelines recommend lipid and glucose testing for all male patients over the age of 40 and for all female patients over the age of 50 regardless of the presence of other pre-cursive AMI risk factors (CDA, 2008; Daskopoulou et al., 2012; Tobe et al., 2011).

While considerable research has focused on the utilization patterns for treatment approaches following AMI, very little research has examined the use of basic preventive diagnostic services employed in primary care to detect the presence of key risk factors (Stange, 2009). This dearth of research related the role of primary care in addressing risk factors for AMI is somewhat surprising given the preventable nature of heart disease and the fact that many established AMI risk factors are amenable to primary care intervention (Franklin & Cushman, 2011). In order to better understand the role of prevention across the continuum of care for AMI, there is a need to explore the use of primary and secondary preventive services in primary care according to clinical practice guidelines to determine whether or not prevention of AMI in primary care is optimal in Canada (Schiele et al., 2005).

## Cost

Research examining the Cost objective of the Triple Aim framework for AMI is more limited (Tarride et al., 2009). This is surprising given the national and provincial policy emphasis that is placed on healthcare spending, particularly for cardiovascular diseases which are well recognized for their material direct and indirect economic impacts in Canada (Smolderen et al., 2010).

Where robust costing information does exist for AMI in Canada, it is almost exclusively focused on the acute care sector (CIHI, 2008a; Azoulay et al., 2003). According to CIHI in 2005, AMI was identified as the highest costing medical condition for inpatient hospitalizations in Canada at 510.8 million annually, and making up 3% of all inpatient hospital costs for the year (CIHI, 2008a). According to the Institute, hospital costs are largely driven by the number of hospital

stays and the average cost per stay for a particular disease condition. With a national average cost per stay estimated at \$11,043 and 46,295 total number of stays in Canada in 2005 (excluding Quebec), AMI represents a significant burden on health system resources and spending within the acute care sector (CIHI, 2008a).

Costing research in Canada focused on specific AMI-related procedures is very limited. One study did examine total healthcare costs for five specific AMI-related services in a population based analysis. Alter et al. (2006) examined trends in total costs for echocardiography, stress testing, catherization, PCI, CABG in Ontario, Canada from 1992 to 2001. Total 2001 costs were found to be 65 million for echocardiography, 18 million for stress testing, 60 million for catherization, 65 million for PCI, and 147 million for CABG, in Ontario. However, as these costs were calculated based on the total population, the average AMI patient cost could not be established. One of the critical findings of this study was the nearly two-fold increase in total spending for each the coronary procedures examined over the ten year period studied (1991-2001). This finding highlights the growing economic burden of AMI diagnosis and treatment on Canadian health systems, and points to the need for more complete costing research to assist policy makers to track and manage healthcare spending in relation to optimal health outcomes.

A number of research papers have also examined AMI cost drivers for inpatient costs, although these studies have been conducted in countries other than Canada (Gu & Yuan, 2013; Krumholz et al., 1998; Wang et al., 2013). In an early study, Krumholz and colleagues (1998) examined major cost drivers for in-hospital AMI costs in the United States for patients 65 years and older. Within this senior cohort, this study demonstrated that increasing age was a negative cost driver for AMI in-hospital costs, while the presence of recognized risk factors and co-morbidities such as hypertension, diabetes, and chronic heart failure were significant positive cost drivers of in-hospital spending. Further, this study pointed to the role of specific in-hospital procedures in predicting in-hospital costs. In particular, patients who received CABG, PCI, angiography, and echocardiogram, as well as the guideline-based pharmaceutical therapies had significantly higher costs than patients who not receive these services. While these study results are somewhat unsurprising and are consistent with more current international literature (Gu & Yuan, 2013; Wang et al., 2013), to our knowledge an examination of in-hospital cost drivers for AMI in the Canadian context has not yet been conducted.

To our knowledge, no costing study has examined the cost and cost-drivers of AMI using a patient-centric approach in Canada. A patient-centric costing approach would necessarily be oriented along the continuum of care, in which a patient's healthcare costs would be quantified across the care trajectory, from preventive primary care, to treatment in acute care, to disease management following the AMI event (Kodner, 2009). Establishing this patient-centric costing and cost-driver information across the continuum of care, will provide decision makers with a unique set of baseline costing data that can be used to measure, monitor and evaluate progress as organizations pursue the balanced goals of the Triple AIM for AMI in Canada.

### Equity

The issue of equity in healthcare is particularly relevant in the Canadian context, in which the universal care principle is driven by the notion of 'equal care for equal need' (Badgley & Wolfe, 1992; Hanratty et al., 2007). According to the Triple Aim Framework, equity is a lens through which all other goals - care, cost and outcomes, must be examined in order to ensure that healthcare is utilized appropriately by all members of the population (Berwick, 2008). This thesis dissertation takes the position that a universal health care system is an important feature of society to create the conditions for equitable health status (Adler & Stewart, 2010; Lalonde, 1974; Naylor, 1992). The goal of ensuring equity in healthcare is two-fold; healthcare has a role in reducing gaps in health outcomes, but also in reducing gaps in the healthcare processes themselves. According to this viewpoint, equity in health care does not always result in equity in health, but an equitable health care system should at least serve to reduce "existing unfairness .....and ensure that the poor are not multiply deprived" (Culyer, 2007, p.15).

To date, a considerable body of research has examined sector-specific inequities for AMI, particularly for services within the acute care sector. In 1999, researchers demonstrated that patients residing in the highest SES neighbourhoods had higher use of coronary angiography and catheterization following AMI, as compared to patients residing in lower income neighbourhoods. This finding led the researchers to point to the importance of coronary angiography as an important rate limiting step for equity in the acute care process following AMI (Alter et al., 1999). Over the last decade, studies in Quebec and in other countries have found similar results, demonstrating a reverse gradient in SES and the use of cardiac catheterization (Anderson et al, 1993; Pilot et al., 2003, Perelman et al. 2009). This research demonstrates that

despite the universal nature of the healthcare system, some inequities in AMI care do exist within the acute care sector.

Equity research in the primary care sector has traditionally examined disparities in overall access to family practitioners and specialists for the general population (Veuglers & Yip, 2003).

However research examining potential inequities in specific AMI preventive services is much more limited. As a result, inequity in the AMI patient care trajectory across sectors is currently difficult to articulate. One recent study examined equity in patients' use of family practitioners and specialist practitioners in primary care in the years preceding the AMI event (Alter et al., 2011). Results revealed that the use of GP services prior to AMI was higher for low SES patients as compared to high SES patients, likely reflecting the higher heart-health needs within low SES patients (Hanratty et al., 2007; Tanuseptro et al., 2003). This research found no differences between SES groups however, in the use for cardiology specialists (Alter et al., 2011). Given the generally poorer heart-health of low SES populations, this finding may reflect an established pattern of inequity in access to specialists for low SES AMI patients.

While this study took a first step in teasing apart potential inequities in preventive primary care for AMI patients at the physician level, potential inequities in specific AMI-related preventive services may have been masked (Stange, 2002). In particular, key diagnostic tests including ECGs, stress tests, echocardiograms, lipid and glucose testing, can be performed by both family practitioners and cardiology specialists within the primary care sector. Without examining the socio-economic differences in the use of these specific services, it will continue to be difficult to fully determine where and how inequities in primary care may be acting (Stange & Ferrer, 2009).

## Outcomes

Health outcomes research related to AMI is well developed. The majority of this research has focused on survival outcomes following AMI in relation to the use of a specific medical or pharmaceutical therapy. Most of the treatment-outcomes research has focused on two key healthcare interventions with 30-day, 90-day, 1 year, and five year survival follow-ups (Bata et al., 2006). The use of PCI is often compared with the more traditional CABG intervention, to determine if one therapeutic modality is more effective than the other over the short or long term. While there has been some disagreement within the literature as to which procedure produces the

best patient outcome, in general both approaches have been found to be equally beneficial from a survival perspective. According to a recent systematic review of the treatment-outcomes literature for AMI, Bravata et al (2007) found that short-term (30 day) survival was high for both PCI and CABG procedures (98.9% for PCI and 98.2% for CABG). Long term survival outcomes for the two procedures were similar at one-year, (96.4% for CABG vs 95.5% for PCI), and at five years also (90.7% for CABG and 89.7% for PCI).

Pharmaceutical interventions have also been evaluated for AMI. In particular, the post-AMI survival benefits of Beta Blockers and statin therapy have been well documented, with both therapies shown to improve survival outcomes following AMI. In systematic reviews focused on outcomes associated with Beta Blocker and statin use, both drug classes were found to reduce all-cause mortality following AMI (3-30% reduction in the risk of death for Beta Blockers and 8-20% risk of death for statin therapies over one year) ( Naci et al, 2013; Freemantle et al., 1999).

While this body of research makes a valuable contribution at the clinical level in the pursuit of cost-effective treatments for patients with AMI, it fails to inform the cost-outcomes relationship at the system level. Key policy questions about whether or not higher overall health system use produces better patient outcomes for AMI remain elusive. While it may be clear that treating an AMI patient with PCI or CABG can reduce risk of mortality, it is unclear whether a patient's overall intensity of service use relates to reduced mortality risk in the same way.

To respond to this policy issue, some studies at the patient level have attempted to examine the relationship between health service intensity and patient survival outcomes using a number of different approaches. This research is quite limited however, and has been conducted by a small number of researchers in the United States and Europe. Study results have demonstrated a relationship between higher overall spending and survival outcomes for AMI patients (Newhouse & McClellan, 1998; Schreyogg & Stargardt, 2010; Stargardt et al., 2013), however this research has yet to be applied in the Canadian context.

In addition to the dearth of patient level cost-outcomes AMI research, the existing research is plagued by a number of methodological biases related to the time-dependent nature of healthcare spending and patient survival (Austin et al., 2006). Patients who are low-cost users because they die before they can receive life-saving care will undoubtedly appear to have poorer outcomes,

while patients may become high-cost users solely as a result of having survived long enough to achieve 'high-cost' status. As a result, the seemingly simple health system policy question, "Is more actually better?" is challenging to untangle. This form of time-dependent bias has been largely unaddressed within the current research (Austin et al., 2006; van Walraven et al., 2004b), and calls into question the general findings of the studies available. This methodological issue represents a significant challenge in the health system literature for AMI, and must be addressed in future cost-outcomes studies for AMI in Canada.

Because the framing of continuum of care research is person-oriented by design, it is critical to understand the way in which AMI health service intensity (and corresponding costs) relate to the predicted survival outcomes at the patient level (Hollander et al., 2009). Without this information, policy makers will continue to struggle with their basic understanding of return on investment in healthcare (Blomqvist & Busby, 2012).

## GUIDING FRAMEWORKS AND THEORY

Many factors are influential in determining health service utilization patterns for patients across the continuum of care including accessibility of care, patient knowledge of illness, perceptions of health services efficacy, distribution of services and providers of care, broader system economics, provider patient partnerships and others (Raphael et al., 2003; Rehban, 2010). The utilization of healthcare services can be viewed as a choice made primarily by the individual requiring care (Rosenstock, 1966), or as a set of determinants operating largely at the societal level (Anderson & Newman, 1974; Frohlich et al., 2001). Much of the current research and policy approaches consider both individual and societal aspects as they give rise to health service utilization patterns (Pearson et al., 2011; Raphael et al., 2003)

In 1974, Anderson and Newman developed a framework for health services utilization that attempted to integrate individual and structural determinants of health into a single model. Today, despite the age of the framework, it continues to be a strong reflection of mainstream thinking about health services utilization in Canada. As such this framework is useful in conceptualizing the notion health service utilization and provides a foundation to guide the research and the interpretation of results. This framework is most useful in that it provides a breakdown of utilization into its component parts, ‘type’, ‘purpose’ and ‘unit of analysis’. ‘Type’ of health service refers to whether physician, hospital, long term care or some other service is being utilized. ‘Purpose’ refers to distinctions between primary care and its focus of prevention, secondary care and its focus on treating specific illness, and tertiary care and its focus on long term chronic conditions. ‘Unit of analysis’ refers to different ways that utilization can be measured including the volume or frequency of services, initial or follow up contact, and episodic care patterns over time (Anderson & Newman, 1974). Each of these components represents unique aspects of utilization that can be used to examine care patterns.

Anderson and Newman’s framework (1974) informs the current project by assisting in defining and framing the concept of utilization and in identifying major structural and individual determinants that influence utilization patterns. The framework however is limited by the fact that it places very little emphasis on the sequential pattern of utilization across the continuum of care. This may be in part due to the fact that the framework was established in the 1970’s; a time when specialization of care for acute health conditions was as a priority strategy for high quality

care. Over the last forty years however, the focus in healthcare has shifted from acute illness to chronic conditions based on the evolving needs of the population (Barr et al., 2003; Epstein & Street, 2011). Under this new set of priorities, the health care system has become substantially more complex, technologies have evolved, and patients are being seen by an increasing number of care providers (Bodenheimer, 2008). In response, a shift to redefine quality of care to meet changing demands is now underway. According to Epstein and Street (2011, page 1), a focus on “patient-centred care has now made it to centre stage in discussions of quality”. This philosophy of patient-centred care acknowledges the central role of the patient in influencing the care utilization trajectory as well as the patient’s impact on the overall health system (Matheson & Neuwelt, 2012).

Put forward as a central philosophy for good quality care by the Institute of Medicine in 2001, person-centred care has become increasingly embedded into healthcare policy across North America and Europe (IOM, 2001; Epstein & Street, 2011). Person-centred care has become part of the lexicon to describe well-functioning healthcare systems (Epstein & Street, 2011). The person-centred care philosophy embodies the goals of the Triple Aim by acknowledging the role of the patients, their families, clinicians and health systems in contributing to a balanced approach to care that delivers quality cost-effective care and achieves optimal patient outcomes (Juhnke & Muhlbacher, 2013). It is important to note that person-centred care does not simply espouse patient satisfaction as its primary objective, but instead reinforces the need for partnership and collaboration between the individual patient and the care provider, and between the set of organizational features within the system, to enable the best possible care coordination and outcomes for each unique patient within the system (Matheson & Neuwalt, 2012).

The person-centred care approach is useful for framing the work of the present thesis dissertation. It reflects the advancements in thinking about care and care processes, in which the patient is at the centre of the care paradigm (Pelzang, 2010). This approach is considered central to the Triple Aim vision, in order to optimize seamless delivery of quality care and ensure cost-effective systems (Kodner & Spreeuwenberg, 2002).

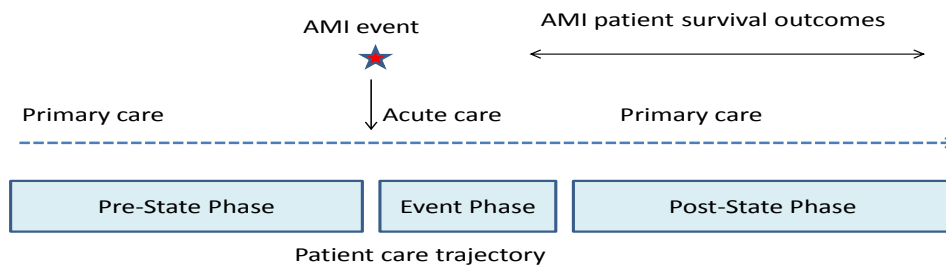
## METHODOLOGICAL OVERVIEW

### General Approach

This thesis employed quantitative methods to examine the four aspects of the Triple Aim framework- care, cost, outcomes and equity. The research was based on health administrative data available through Ontario’s Institute for Evaluative Sciences (ICES). In each study, Haggerty et al.’s (2003) notion of continuum of care research was reflected – one in which care is delivered *to a person over a period of time*, to frame the research question and or the interpretation of results. Each study focused on a particular aspect of the Triple Aim - care, cost, outcomes and equity, responding to gaps in the literature for AMI.

The AMI patient care trajectory was framed in three phases, according to a patient-centric model developed by O’Brien et al (2003). This model was originally developed to examine diabetes costs across a typical patient care trajectory, but the model itself adapts well to patients with AMI. The three phases of the model correspond to a patient’s care trajectory through time. First, AMI services utilized in primary care prior to the AMI event were assigned to a patient’s ‘pre-state’ phase of care. Second, AMI services utilized within the acute care sector as a result of the AMI event were assigned to the patient’s ‘event’ phase of care. Third, AMI services utilized in the primary care sector following discharge from hospital were assigned to the patient’s ‘post-state’ phase. See Figure 1 for a conceptual diagram.

Figure 1: Conceptual Representation of the AMI Patient Care Continuum



Each study in this thesis dissertation focused on a particular phase (or phases) of a patient's care continuum. Study 1 examined the pre-state phase of care to explore AMI patient's use of preventive care services in primary care. Study 2 examined the complete care continuum for AMI patients, from pre-state, to event, to post-state phases to detail a complete patient cost along the care trajectory. Study 3 examined relationship between the event phase and patient survival outcomes to explore the relationship between cost and outcomes for AMI patients in Canada.

### *Defining the AMI cohort*

CIHI's Discharge Abstract Database (DAD), housed at ICES was used to identify the study cohort. All patients between the ages of 40 and 105 who were admitted to Ontario hospitals with a first-time most responsible diagnosis of AMI (ICD-10 code (I21)) were included in the study. Specific time frames for the research varied depending upon the study, however all studies took place between 2004 and 2012. Incident AMI cases were determined by selecting only those patients for whom the absence of a hospitalization for AMI could be established for up fifteen years prior to the index AMI. Patients were required to be residents of Ontario for the duration of the study period to ensure that all services could be accurately tracked across the care continuum. In each study patients living in the Kingston/Quinte/Rideau region were excluded due to alternative billing arrangements in which services could not be captured with available data sources.

### *Data Sources*

Patient records were linked using deterministic linkage via the population registry at ICES across the complete care continuum until death or censoring. Specific data sets included the Canadian Institute for Health Information's DAD, the Ontario Physician Claims Fee-for-Service Database, Ontario's Laboratory Services Database, Ontario Drug Benefits database, and the Ontario Registered Persons Database maintained by ICES (See Appendix A for details). These data holdings contain hospital, physician, pharmaceutical, and lab claims, and vital statistics data for all residents of the province of Ontario. It should be noted that the Ontario Physician Claims Database houses data for only physicians paid by fee-for-service (approximately 95% of the total physician expenditures in Ontario)(Potter et al., 2005), and the Pharmaceutical Claims Database contains complete coverage for the Ontario population over the age of 65 (Hux et al., 2006).

Census data (2006) from Statistics Canada were used to assign socio-economic status, and urban or rural status, to each patient by postal code area of residence as determined by median neighbourhood income and location of residence according to Statistics Canada standards (ICES, 2014).

#### *Approach to Examining AMI Services*

Key services for AMI prevention, diagnoses, and treatment were included in the present research. Specific fee codes from the Ontario Physician Billing Database and ICD-10 Canadian Classification of Health Interventions (CCI) service codes from the Discharge Abstract Database made up the set of services examined. Fee codes and CCI codes studied were adapted from Tu et al.'s 2001 research which was used to establish the Ontario Myocardial Infarction Database at ICES and Ontario Myocardial Prediction Rules over ten years ago (ICES, 2014). Across the three studies, services generally included lipid and glucose testing, ECG, echocardiogram, stress testing, angiography, PCI, CABG, physician consults, and the cardiac drug classes ace inhibitors, beta blockers, statins, and calcium channel blockers across the AMI patient's care continuum. For a complete list of codes, see Appendix B.

#### *Identifying AMI and Co-morbid Illness*

All patients were identified for inclusion in the study cohorts based on a first-time most responsible diagnosis of AMI (ICD-10 code (I21)) within the CIHI DAD. Patient records were checked at least fifteen years prior to the index event to ensure that only incident AMI cases were selected for inclusion. Relevant co-morbid illnesses were identified on patient records as secondary diagnosis within the CIHI DAD, based on Tu et al.'s (2001) Ontario AMI mortality prediction rules. Diagnosis Type 1 and 2 data were not available for use to assist in determining the timing of co-morbid illnesses (pre-admit or post-admit co-morbidities). As a result, in study 1, co-morbid illnesses were not included as control variables in the regression models.

#### *Statistical Approaches*

The statistical approach varied depending upon the research question and methodology within each specific study. In general, basic statistical and epidemiological methods were applied wherever possible. Advanced statistical approaches were used when necessary to address

challenging data distributions and data modelling issues. In particular, for Study 2, zero-inflated negative binomial regression models were required to examine the relationship between specific patient cost-drivers and actual patient costs within the pre and post-state phases of care (Lewesy & Thompson, 2004). This method was used to address the challenges with modelling cost as the dependent variable. The cost data were heavily right tail skewed, but also had a substantial number of zeros within the pre-state and post-state phases of care. For Study 3, an Extended Cox survival model was used to address the time-varying nature of costs, in order to study the relationship between patient costs and one-year outcomes (Allison, 2010). This method was required to address a key form of bias called survivor-treatment selection bias (van Walraven et al., 2004b) See each study for specific details regarding statistical methods. Each study was approved by the Ottawa Hospital Research Ethics Board, Ottawa, Ontario, Canada. SAS 9.2 was used in each study to analyze results.

## THESIS OVERVIEW AND ORGANIZATION OF THE DISSERTATION

This thesis was pursued in a ‘thesis by papers’ approach in which three separate research questions and corresponding papers were undertaken. As such, each paper represents a distinct and focused piece of research. The specific focus of each paper was considered in terms of its contribution to this overall thesis dissertation. Each paper will be presented in the following chapters according to dates of development. Following these chapters, a summary and conclusions chapter will frame the findings according to the broad overall thesis objectives. Future research questions and next steps are then presented.

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## Appendix A – Overview of Data Sources

<b>Data Source</b>	<b>Description</b>	<b>Relevant Information Provided</b>	<b>Coverage</b>
<b>CIHI Hospital Discharge Abstract Database</b>	This database contains demographic patient data, clinical diagnosis data and procedural data for all hospital facility-based encounters in Canada. (1979-2013)	Patient health card number, age, sex, AMI diagnosis, presenting co-morbidities, in-hospital AMI related procedures	All inpatient hospitalizations of AMI for residents of Canada. Available through ICES for Ontario residents.
<b>Ontario Physician Claims Fee-for-Service Database</b>	This database contains service billing data by family physicians and specialists for all services billed by fee-for-service to OHIP. (1991-2013)	Patient health card number, physician service billing codes, physician specialty	All physician claims remunerated by fee-for-service through OHIP (approximately 95% physician expenditures in Ontario). Covers all residents of Ontario.
<b>Ontario Laboratory Services Database</b>	This database contains laboratory service data for all laboratory claims billed to OHIP. (1991-2013)	Patient health card number, laboratory service billing codes	Covers lab services covered by OHIP. Covers all residents of Ontario.
<b>Ontario Drug Benefits Database</b>	This database contains prescription drug claims paid for by OHIP. (1990-2013)	Patient health card number, prescription drug claims relevant to coronary heart disease	Covers drug claims for residents of Ontario who are 65 and older.
<b>Ontario Registered Persons Database</b>	This database contains anonymized information about all residents of Ontario who have ever been assigned an Ontario health card number. (1990-2014)	Linkage key, vital statistics	All residents of Ontario holding a health card.

## Appendix B – Physician Billing Service Codes for Acute Myocardial Infarction Included in this Dissertation

<b>Service Category</b>	<b>Fee Codes/Service Codes</b>
ECG	G175, G307, G308, G310, 311, G313, G317, G321, G650, G651, G652, G653, G654, G655, G656, G657, G658, G659, G660, G661, G681, G682, G683, G684, G685, G686, G687, G320, G688, G689, G690, G692, G693
Echocardiogram	G560, G561, G562, G566, G567, G568, G570, G571, G572, G574, G575, G578, G581, G577
Stress Testing	G315, G319, G311, G112, G174
Lipid and Glucose Testing	G001, G013, L117, L151, L152, L153, L154, L155, L156, I193, L243, L055, G002, G498, L103, L104, L111, L112
Nuclear Imaging	J802, J602, J804, J604, J867, J667, J806, J606, J866, J666, J808, J608, J809, J609, J810, J610, J811, J611, J812, J612, J813, J613
General Practitioner Services	A001, A003, A004, A005, A006, A007, A008, A055, A071, A073, A074, A075, A076, A078, A093, A094, A095, A096, A131, A133, A134, A135, A136, A138, A435, A405, A601, A603, A604, A605, A606, A608, A675, A901, A905, A100, A888, A933, E079, K039
Cardiology Services	C002, C003, C004, C005, C006, C007, C008, C009, C010, C055, C092, C093, C094, C095, C096, C097, C098, C099, C101, C121, C122, C123, C124, C131, C132, C133, C134, C135, C136, C137, C138, C139, C142, C405, C435, C601, C602, C603, C604, C605, C606, C606, C607, C608, C609, C675, C905, C935, C933
Intensive Care Unit	G400, G401, G402, G405, G406, G407, G557, G558, G559
Emergency Services	H065, H102, H103, H101, H104, H132, H134, H152, H151, H153, H122, H123, H121, H124
Catherization/Angiography/ Percutaneous Coronary Intervention (PCI)	Z442, G297, Z439, Z440, Z441, G296, G299, G289, G300, G301, G306, G305, G509, G263, Z434, G262, G298, Z448, Z449, Z460, Z461
Coronary Artery Bypass Grafting (CABG)	R742, R743, E654, E645, E654, E652, E646

## Chapter 2

**Full title:** Inequity in primary and secondary preventive care for AMI? Utilization by socioeconomic status across middle-age and older patients

**Short Title:** AMI Preventive Care by Age and SES

**Authors:**

Deborah Cohen, MA, Department of Population Health, University of Ottawa, Ontario, Canada

Douglas G Manuel, MD, FRCPC, MSc, Ottawa Hospital Research Institute, University of Ottawa, Institute for Clinical Evaluative Sciences, Ontario, Canada

Peter Tugwell, MD, FRCPC, MSc, Centre for Global Health, Institute of Population Health, Ottawa Health Research Institute, University of Ottawa, Ontario, Canada

Tim Ramsay, PhD, Ottawa Hospital Research Institute, Department of Epidemiology and Community Medicine, University of Ottawa, Ontario, Canada

Claudia Sanmartin, PhD, Health Analysis Division, Statistics Canada, Ontario, Canada

**Corresponding Author:** Deborah Cohen

**Table Count:** 4

### Abstract

**Background:** Limited research has explored socioeconomic inequity in targeted preventive care for acute myocardial infarction (AMI). The objective of this study was to examine socioeconomic disparities in the use of primary and secondary preventive services relevant to the identification and management of heart disease in a cohort of AMI patients.

**Methods and Results:** Preventive services utilized prior to AMI were examined in a cohort of 30,491 first-time AMI patients in Ontario, Canada, from 2010 to 2012. Using logistic regression, socioeconomic differences in lipid-testing, glucose-testing, stress-testing, electrocardiograms, and echocardiograms in middle-age and older patients were examined.

**Results:** For many of the services, there were no differences in the use of primary and secondary preventive services between patients by socioeconomic status. A number of exceptions were found. For primary preventive services, low income middle-age patients had 13% (95% CI=0.790-0.967) and 10% (95% CI=0.812-0.997) lower odds of receiving lipid and glucose-testing respectively compared to high income middle-age patients, when other factors were controlled for. For secondary preventive services, low income middle-age and older patients had 24% (95% CI=1.087-1.415) and 10% (95% CI=1.012-1.202) higher odds of receiving echocardiograms compared to their high income counterparts, controlling for other factors.

**Conclusion:** Socioeconomic disparities in primary and secondary preventive services for AMI could not be demonstrated in many instances. However, inequities in primary preventive care were found in middle-age patients utilizing lipid and glucose testing, which may have implications for Canadian health policy to ensure healthy aging across the age spectrum.

**Key words:** Myocardial infarction, prevention, primary care, disparity

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## Inequity in Primary and Secondary Preventive Care for AMI? Utilization by Socioeconomic Status in Middle-age and Older patients

A considerable body of research has demonstrated that socioeconomic inequities exist in health service use following acute myocardial infarction (AMI). In many Western countries marked differences favouring individuals of high socioeconomic status (SES) have been observed in the rates of cardiac catheterization, coronary angioplasty, coronary artery bypass grafting, and cardiac rehabilitation in high-risk patient populations.<sup>1-5</sup> Canadian research has demonstrated similar patterns of inequity in AMI therapeutic care, despite the universal nature of its healthcare system in which financial barriers to physician and hospital services are mitigated via progressive tax-based financing.<sup>6-9</sup>

In spite of the established patterns of inequity in therapeutic health care for AMI, there exists a paucity of research that has examined inequity in AMI prevention in primary care. This is surprising given the preventable nature of heart disease and the fact that many established AMI risk factors are amenable to primary care intervention.<sup>10-12</sup> Most primary care research focused on inequity has examined disparities in access to general practitioners and specialists within the general population.<sup>13-16</sup> However there has been limited focus on disparities in primary and secondary preventive services related to the early diagnosis and management of heart disease in high-risk patient populations.

The purpose of this study was to explore disparities in the use of primary and secondary preventive diagnostic services relevant to the identification and management of heart disease. *Primary prevention* was defined as services in primary care used to delay or prevent the onset of cardiovascular disease (MeSH term – National Library of Medicine). Services examined included lipid and glucose testing. *Secondary prevention* was defined as services in primary care that focus on the early detection and management of disease (MeSH term – National Library of Medicine). Services examined included stress-testing, electrocardiogram (ECG), echocardiogram. We conducted a linkage study with a cohort of first-time AMI patients in Ontario, Canada and looked back retrospectively at the use of preventive services for two years prior to AMI. We examined socioeconomic differences in the use of each preventive service, stratified across middle-age and older patients. Given the universal nature of Canada's healthcare system in which financial barriers to care have been removed, we hypothesized that

low SES patients should not experience a lower use of any preventive care service compared with higher income patients in this AMI cohort.

## Methods

### Data sources

Data from the Canadian Institute for Health Information's Discharge Abstract Database was used to identify all patients in the population who were admitted to Ontario hospitals with a primary diagnosis of AMI (ICD-10 code I21) between April 1, 2010 and March 31, 2012. Coding accuracy of AMI diagnostic codes in administrative health data has been validated in previous research.<sup>17,18</sup> To control for differences in severity of cardiovascular disease, only first-time AMI patients between the ages of 40 and 105 were included. We established incident cases by selecting only patients with no other AMI hospitalizations for up twenty years prior to the index event. Patients were excluded if they were not residents of Ontario at any point during the study period. Patients living in the Kingston/Quinte/Rideau region were excluded due to alternative billing arrangements in which preventive services could not be captured with Ontario's Hospital Insurance Plan (OHIP) fee-for-service billing data. All AMI inpatient records were linked via unique encrypted identifiers with outpatient records in the OHIP database.

### Age Group and SES

Age has been shown to be the largest non-modifiable risk factor for AMI.<sup>19</sup> Given that care profiles may be influenced by age, the study cohort was divided into two age groups. Patients were coded as 'older' if they were 65 and over at the time of the AMI event. All other patients, aged 40 to 65, were coded 'middle-aged'.

Because SES is not part of the administrative health record in Ontario, area-based income was assigned at the dissemination-area by linking the full six-digit patient postal code with 2006 Census neighbourhood before-tax, personal-income, Ontario data (Statistics Canada). The cohort was partitioned into individual income quintiles that contained roughly equal proportions of the Ontario population. AMI patients assigned to the first two income quintiles were coded 'low income', patients assigned to the third and fourth quintile were coded 'medium income', and those in the fifth quintile were coded 'high income'.

### In-Hospital Case Mix

Given that the study design included only AMI patients, all subjects in the cohort were assumed to have a high severity of disease. However we further examined inpatient co-morbid illness as a measure of case-mix, based on Ontario AMI mortality prediction rules to approximate variations in co-morbidity amongst the patient cohort.<sup>20</sup>

### Primary and Secondary Prevention

Primary and secondary preventive diagnostic services were examined for each patient. Primary preventive services included lipid and glucose-testing. Secondary preventive services included stress-testing, ECG, echocardiogram. Each of these diagnostic tests are considered routine, non-invasive, primary and secondary preventive services for AMI and are included in a number of clinical practice guidelines for the prevention of cardiovascular disease.<sup>19, 21-25</sup> Blood pressure testing was not captured in this dataset. Patients were counted as having had a preventive service when at least one billing code was recorded within the two years prior to the AMI. A two year look-back window was selected for this study to ensure that preventive services examined could be reasonably associated with the AMI event.

### Statistical Analysis

We examined differences in patient characteristics, case-mix and service use across high, medium, and low SES. The Cochran Mantel-Haenszel test was used to test for differences in categorical variables and analysis of variance was used for continuous variables. Case mix differences were stratified by middle-age and older patient status, and a Bonferroni correction for multiple testing ( $\alpha=0.001$ ) was applied. We calculated unadjusted utilization rates to determine the proportion of AMI patients receiving each preventive care service. We applied logistic regressions, stratified by middle-age and older patient status, to examine the main effect of SES on the likelihood of having each preventive service, while also controlling for age, sex and rural or urban patient residential status. Collinearity among predictor variables was determined to be acceptable based on a variance inflation factor cut-off of ten.<sup>26</sup> The Chi-Square Wald statistic was used to determine the contribution of the main effect of SES in the model, and odds ratios were used to measure the effect size between SES groups. The study was approved by the Ottawa Hospital Research Ethics Board, Ottawa, Ontario, Canada.

## Results

### *Patient Characteristics*

The AMI cohort included 30,491 patients where 57.9% (n=17651) were older patients and 42.1% (n=12840) were middle-aged. The average patient age was 68.6 years. Patients of higher income were slightly older and significantly more likely to be male (Table 1).

### *Co-morbid illness*

Examination of inpatient co-morbid illness indicated a relatively homogeneous case-mix among SES groups (Table 2). Comparative analyses produced few differences between low, medium and high income patients in the middle-aged or older categories. However, chronic heart failure (CHF) was more prevalent among lower income patients in both middle-age and older categories respectively (6.0%, 4.5%, 3.6% for low, medium and high income middle-age patients;  $p<0.0001$ ) and (21.6%, 19.8%, 18.5% for low, medium and high income older patients,  $p=0.001$ ). Acute renal failure and diabetes with complications were more prevalent among lower income patients in the middle-age category (1.7%, 1.3%, 0.8% for acute renal failure among low, medium and high income middle-age patients;  $p=0.0008$ ) and (3.0%, 1.9%, 1.4% for diabetes with complications among low, medium and high income middle-age patients;  $p=<.0001$ ).

### *Preventive Care*

Table 3 shows the unadjusted rates of service use for each primary and secondary preventive service. Among the entire cohort, 64.4% of the patients received lipid-testing, 72.5% received glucose-testing, 16.0% received stress testing, 67.8% received ECG, and 28.5% received echocardiogram. Older patients used more of every type of service.

Logistic regression analyses demonstrated that SES was a not a significant predictor of six-out-of-ten services studied, when other factors were controlled for (Table 4). For the two preventive primary services studied, lipid and glucose-tests, significant differences favouring high income patients were found among middle-aged patients. Low income, middle-age patients had 12.6% (95% CI=0.790-0.967) and 10.0% (95% CI=0.812-0.997) lower odds of receiving lipid and glucose testing respectively than high income patients when other factors were controlled for. For secondary preventive services, significant differences in SES were not found for stress tests

or ECG in either age category. For echocardiogram, socioeconomic differences were found in which low income patients received significantly more care in both middle-age and older age categories. Low income middle-age patients had 24.0% (95% CI=1.087-1.415) higher odds, and low income older patients had 10.3% (95% CI=1.012-1.202) higher odds of receiving echocardiograms than their high income counterparts when other factors were controlled for.

## Discussion

Consistent with our hypothesis, this study demonstrated that low SES patients did not experience a lower likelihood of health service use compared to high income patients for many of primary and secondary preventive services examined. Where significant differences in care were found, gaps that demonstrated an under-use in care among low SES patients were found only in primary preventive services, lipid and glucose-testing. Remaining socioeconomic differences in echocardiogram services revealed a reversed SES gradient in which low income patients had a higher likelihood of receiving care than high income patients. Contrary to primary preventive care patterns, this reversed SES gradient in echocardiogram services may be evidence of the ‘equal care for equal need’ principle operating in secondary preventive care for AMI.<sup>27</sup>

For the primary preventive services studied, a significant difference in the use of lipid and glucose-tests among middle age patients was observed. High income patients had significantly higher odds than low income patients of receiving at least one of these preventive services, suggesting some inequity within primary preventive care. Clinical practice guidelines for heart disease recommend lipid and glucose-testing for men and women over the age of 40 (pre-menopausal women over 50 for lipid testing) regardless of atherosclerotic symptomatology.<sup>21,23,25</sup> Given that the cohort included only those patients who had AMI, it would be reasonable to expect that the majority of the patients should have received testing regardless of income. However, study results for middle-aged patients demonstrated a 12% and 10% difference in the likelihood of receiving lipid and glucose-testing respectively between the highest and lowest SES groups. Although the size of the socioeconomic gap for either test was not large, these findings do raise some concern about primary preventive care for AMI within younger age groups. Canada’s healthy aging policy promotes a set of lifelong processes that preserve health and prevent disease in seniors and middle-age individuals in order to optimize health outcomes across the population.<sup>28</sup> The equitable primary preventive care patterns

observed in older patients may suggest that current seniors programs are effective in achieving goals around primary prevention for older patients. However the inequitable patterns of care observed in middle-age patients point to the need for improved focus on primary preventive care in younger age groups to ensure healthy aging across the age spectrum.<sup>29</sup>

For secondary preventive care services, no socioeconomic differences in the utilization of stress-testing or ECG were found. This finding was consistent with the study hypothesis that no differences in care between SES groups would be expected. However for one secondary preventive service, echocardiogram, a socioeconomic difference was found. Although in this case, low income patients in both middle-age and older-age categories were significantly more likely to receive care than their high income counterparts. Study results demonstrated a 24% and 10% difference in the likelihood of receiving echocardiogram between the lowest and highest SES groups for middle-age and older patients respectively. This pattern of echocardiogram use favoring low SES patients may be evidence of the ‘equal care for equal need’ principle operating in secondary preventive care for AMI.<sup>27</sup> Previous research has shown that low SES populations have a higher risk of heart disease and poorer outcomes compared to those in higher income quintiles.<sup>10,30,31</sup> It is possible that the inflated heart-health risk among low SES patients may have resulted in the increased likelihood of use of echocardiogram in this study. Low income patients may have been more likely to present to physicians with atherosclerotic symptomatology prior to the AMI event, resulting in the amplified utilization of echocardiogram.

### *Limitations*

Several limitations warrant consideration. First, the use of linked administrative health data limited our ability to study individual patient incomes. Instead, a well established methodology was used to assign area-based income based on patient postal code.<sup>32</sup> While this method has been criticized as having potential for misclassification, considerable research has supported area-based income measures particularly when studying seniors because they tend to measure of wealth rather than income which has greater relevance at older ages.<sup>32</sup> Area-based income measures have also been recommended for making comparisons across diverse age groups because individual incomes for retired seniors are not directly comparable to the individual incomes of employed middle-aged persons.<sup>32-35</sup>

In addition, a high-risk patient cohort was selected to create a subject pool with homogeneous healthcare needs so that socioeconomic differences in preventive service use could be directly examined. As a result however, the findings are not generalizable to the general population in which larger socioeconomic disparities in preventive care may be expected as a result of the greater heterogeneity in health status within the population.

### Conclusion

Results from this study demonstrated few socioeconomic differences in preventive care services within an AMI patient cohort. Patterns of echocardiography utilization favoured low income patients, possibly signalling the system's focus on secondary preventive efforts for those with higher need. In contrast however, socioeconomic inequities were identified in lipid and glucose-testing for middle-age patients that may signal a quality of care issue for primary preventive care. These findings may have implications for Canadian health policy to ensure healthy aging across the age spectrum.

## Chapter 2 - References

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Table 1 – Baseline Patient Characteristics According to Neighborhood Income

	Income Group*			P-value ( $\alpha=0.05$ )
	(Low Income)	(Middle Income)	(High Income)	
N	12,860	12,045	5,586	
(%)	(42%)	(40%)	(18%)	
<b>Socio- demographic characteristics</b>				
Age	68.57	68.45	69.02	0.0356
Age range	(42-104)	(42-104)	(42-103)	
Gender (% male)	60.62	65.07	66.56	<.0001
Rural residence	14.36	14.84	13.93	ns
Senior status (% senior)	57.92	57.43	58.79	ns
Personal Income (DA level)				
Median Income	22,672	29,981	35,979	
Mean Income	28,551	36,854	53,486	

\*Area based income methodology was used based on income distribution in the 2006 Ontario Census data from Statistics Canada. Neighborhood income quintiles were arranged such that the lowest two income groups formed the 'low income' group, the third and fourth quintiles formed the 'middle income' group, and the fifth quintile formed the 'high income' group

Table 2: Percentage of AMI patients with co-morbid Illness at time of AMI Event

Co-morbid illness ***	Income Group*			Cochrane Mantel-Haenszel Chi-Square	P-value ( $\alpha=0.001$ )**
	(Low Income) N=12,860	(Middle Income) N=12,045	(High Income) N=5,586		
<b>Shock</b>					
Middle-age	2.00	1.74	1.56	1.96	ns
Older	3.46	3.34	3.53	0.01	ns
<b>Chronic heart failure</b>					
Middle-age	<b>6.01</b>	<b>4.53</b>	<b>3.61</b>	<b>22.98</b>	<b>&lt;.0001</b>
Older	<b>21.55</b>	<b>19.80</b>	<b>18.48</b>	<b>14.80</b>	<b>0.001</b>
<b>Cancer</b>					
Middle-age	1.18	1.03	1.04	0.45	ns
Older	3.77	3.18	3.32	2.42	ns
<b>Cerebrovascular disease</b>					
Middle-age	0.83	0.99	0.78	0.01	ns
Older	2.73	2.99	2.38	0.37	ns
<b>Pulmonary edema</b>					
Middle-age	0.76	0.70	0.43	2.11	ns
Older	1.34	1.69	1.37	0.32	ns
<b>Acute renal failure</b>					
Middle-age	<b>1.74</b>	<b>1.31</b>	<b>0.78</b>	<b>11.15</b>	<b>0.0008</b>
Older	7.44	7.53	6.70	1.22	ns
<b>Chronic renal failure</b>					
Middle-age	1.40	0.98	0.65	9.54	ns
Older	3.61	5.17	4.05	10.43	ns
<b>Diabetes with complication</b>					
Middle-age	<b>2.96</b>	<b>1.89</b>	<b>1.39</b>	<b>21.98</b>	<b>&lt;.0001</b>
Older	2.50	1.72	1.74	9.69	ns
<b>Cardiac Dysrhythmia</b>					
Middle-age	6.15	6.61	5.30	0.87	ns
Older	16.89	16.55	16.17	0.89	ns

\* Area based income methodology was used based on income distribution in the 2006 Ontario Census data from Statistics Canada. Neighborhood income quintiles were arranged such that the lowest two income groups formed the 'low income' group, the third and fourth quintiles formed the 'middle income' group, and the fifth quintile formed the 'high income' group

\*\*Alpha value based on Bonferroni correction for multiple comparisons ( $\alpha=0.001$ )

\*\*\* Co-morbid illnesses based on Ontario Acute Myocardial Infarction Mortality Prediction Rules (Tu et al. 2001)

Table 3 – Percentage of patients with at least one service use in the two years prior to AMI

	Income Groups*			
	(All incomes) N=30,491	(Low Income) N=12,860	(Middle income) N=12,045	(High Income) N=5,586
Lipid Testing - All	64.36	62.99	65.54	64.97
Middle-age		56.75	59.84	60.25
Older		67.53	69.76	68.27
Glucose Testing - All	72.53	71.76	72.98	73.34
Middle-age		61.06	62.29	63.68
Older		79.53	80.62	80.12
Stress Testing - All	15.95	15.45	16.37	16.20
Middle-age		14.97	15.60	14.64
Older		15.80	16.94	17.30
Electrocardiogram -All	67.77	68.43	67.54	66.77
Middle-age		56.72	56.45	54.65
Older		76.94	75.79	75.27
Echocardiogram - All	28.50	29.32	28.29	27.07
Middle-age		18.76	17.52	15.81
Older		36.98	36.28	34.96

\* Area based income methodology was used based on income distribution in the 2006 Ontario Census data from Statistics Canada. Neighborhood income quintiles were arranged such that the lowest two income groups formed the 'low income' group, the third and fourth quintiles formed the 'middle income' group, and fifth quintile formed the 'high income' group

Table 4: Fully Adjusted Logistic Regression Models for Primary Preventive Services Stratified by Middle-age versus Older Patients

	<i>Age Group</i>	<i>p-value</i>	<i>(SES)*</i>	<i>Beta coefficient</i>	<i>SE</i>	<i>Odds ratio</i>	<i>Confidence Interval</i>
<b>Primary Preventive Care</b>							
Lipid Testing	<b>Middle-Age</b>	<b>0.0088</b>	<b>Low vs High</b>	<b>-0.135</b>	<b>0.051</b>	<b>0.874</b>	<b>(0.790-0.967)</b>
		ns	Mid vs High	0.008	0.052	1.008	(0.910-1.116)
	Old-age	ns	Low vs High	-0.019	0.046	0.981	(0.896-1.074)
		ns	Mid vs High	0.085	0.046	1.088	(0.993-1.193)
Glucose testing	<b>Middle-Age</b>	<b>0.0434</b>	<b>Low vs High</b>	<b>-0.106</b>	<b>0.052</b>	<b>0.900</b>	<b>(0.812-0.997)</b>
		ns	Mid vs High	-0.018	0.053	0.982	(0.885-1.089)
	Old-age	ns	Low vs High	-0.031	0.053	0.970	(0.874-1.076)
		ns	Mid vs High	0.045	0.054	1.046	(0.941-1.163)
<b>Secondary Preventive Care</b>							
Stress testing	Middle-Age	ns	Low vs High	0.0401	0.070	1.041	(0.907-1.195)
		ns	Mid vs High	0.091	0.071	1.095	(0.954-1.258)
	Old-age	ns	Low vs High	-0.090	0.057	0.914	(0.818-1.021)
		ns	Mid vs High	-0.016	0.057	0.984	(0.880-1.100)
Electrocardiogram	Middle-Age	ns	Low vs High	0.088	0.050	1.092	(0.989-1.205)
		ns	Mid vs High	0.091	0.051	1.095	(0.991-1.210)
	Old-age	ns	Low vs High	0.096	0.049	1.100	(0.999-1.212)
		ns	Mid vs High	0.031	0.049	1.031	(0.936-1.136)
Echocardiogram	<b>Middle-Age</b>	<b>0.0014</b>	<b>Low vs High</b>	<b>0.215</b>	<b>0.067</b>	<b>1.240</b>	<b>(1.087-1.415)</b>
		<b>0.0375</b>	<b>Mid vs High</b>	<b>0.142</b>	<b>0.068</b>	<b>1.153</b>	<b>(1.008-1.318)</b>
	<b>Old-age</b>	<b>0.0261</b>	<b>Low vs High</b>	<b>0.098</b>	<b>0.044</b>	<b>1.103</b>	<b>(1.012-1.202)</b>
		ns	Mid vs High	0.064	0.045	1.066	(0.997-1.163)

\*Fully adjusted logistic model for each preventive test: (PREVENTIVE TEST = AGE SEX RURAL SES)

### Chapter 3

Full title: Direct Healthcare Costs of Acute Myocardial Infarction in Canada's Elderly across the Continuum of Care

Short Title: Cost of AMI across the Care Continuum

Authors:

Deborah Cohen, PhD Candidate, Department of Population Health, University of Ottawa, Institute for Clinical Evaluative Sciences, Ontario, Canada

Douglas G Manuel, MD, FRCPC, MSc, Ottawa Hospital Research Institute, University of Ottawa, Institute for Clinical Evaluative Sciences, Ontario, Canada

Peter Tugwell, MD, FRCPC, MSc, Centre for Global Health, Institute of Population Health, Ottawa Health Research Institute, University of Ottawa, Ontario, Canada

Claudia Sanmartin, PhD, Health Analysis Division, Statistics Canada, Ontario, Canada

Tim Ramsay, PhD, Ottawa Hospital Research Institute, Department of Epidemiology and Community Medicine, University of Ottawa, Ontario, Canada

Corresponding Author: Deborah Cohen

### Abstract

A growing number of healthcare policy initiatives around the world have focused on the continuum of care amongst the elderly, calling for renewed investments in integrated care to promote healthy aging and to reduce health system costs. The study objective was to examine healthcare costs and cost drivers for myocardial infarction (AMI) among Canadian Seniors across the care continuum from 2004 to 2012 in Ontario, Canada. Cost estimates represented direct community and hospital-based costs including physician services, diagnostic-testing, pharmaceuticals and hospitalizations obtained from Canadian healthcare data sources. Separate costs were calculated for pre-state care, the hospital event, and post-state care over a six year care continuum. Socio-demographic and co-morbid cost drivers were studied using negative binomial regression in a cohort of 16,450 first-time AMI seniors.

The average cost per patient across a six-year care continuum was \$28,169 in 2008 constant Canadian dollars. Almost three-quarters of these costs were derived from the event phase (\$20,794), while pre-state and post-state costs made up 12% and 14% respectively (\$3400 and \$3974). Pre-state costs per patient day were half of post-state costs (\$3.11 versus \$6.32 per day) when adjusted for survival. Socio-demographic characteristics including age, gender and patient's urban/rural residence, and co-morbid illnesses were key cost drivers across the phases of care. This study provides a person-centered health system perspective in the economic burden of AMI in Canada's elderly and will inform health policy related to integrated care strategies for heart disease in seniors.

Key words: Myocardial infarction, continuum of care, acute care, primary care, cost drivers, health spending

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### Chapter 3 - Direct Healthcare Costs of Acute Myocardial Infarction in Canada's Elderly across the Continuum of Care

Acute Myocardial Infarction (AMI) exacts a significant burden of illness world-wide. AMI is responsible for between 40% to 50% of the 17 million annual cardiovascular disease deaths globally (Yusuf, 2001; WHO, 2011), and represents the leading cause of morbidity and mortality in North America (Tu et al. 1997). The impact of AMI on the elderly is particularly profound, with a ten-fold greater AMI incidence among those 65 to 74 as compared to those 35 to 44, and a persistently high case fatality rate for patients over the age of 65 (Roger, 2007; Yazdanyar & Newman, 2009). Given global trends in population aging and the anticipated increase in corresponding AMI health care costs (Heidenreich et al., 2011; Kim et al. 2013;), governments around the world are growing increasingly focused on integrated seniors strategies to address heart disease across the continuum of care in order to promote healthy aging and mitigate healthcare spending (Smith, 2009; Health Council of Canada, 2012; Leatt et al., 2000; Nolte et al., 2008).

The last decade has seen a growing interest in models of care for AMI that promote coordination of services across the care continuum, however there remains limited available evidence about actual costs of AMI across the care trajectory (Nolte et al., 2008). Despite the substantive disease burden of AMI among the elderly, AMI costing research across the care continuum is particularly lacking for those over 65 (Tarride et al, 2009). In the Canadian context, in which a single-payer universal healthcare provides physician, hospital and drug coverage to all seniors, no study has yet examined direct AMI costs in the elderly across the complete continuum of care; exploring costs in community and hospital-based care, both before and after the index AMI event. This is surprising given that seniors have been shown to be among the highest users of AMI healthcare services (CIHI, 2011a; Krumholz et al, 1998) and that integrated care models for seniors in general have been shown to improve health outcomes and cost-savings overall (MacAdam, 2008; Carstairs & Keon, 2009).

The purpose of this study was to examine healthcare costs and cost drivers for AMI among Canadian seniors across the care continuum from 2004 to 2012 in Ontario, Canada. Patient cost data are presented in aggregate but are also delineated in time across the care trajectory to detail the costs of healthcare services prior to AMI, the costs of acute in-patient AMI care, and the

costs of disease management following the AMI event. Finally, socio-demographic and clinical factors that are major drivers of cost along the patient's care continuum are explored.

## Methods

The Canadian Institute for Health Information's Discharge Abstract Database (DAD), housed at the Institute of Clinical Evaluative Sciences (ICES) of Ontario, Canada was used to identify the population-based study cohort. All patients between the ages of 65 and 105 who were admitted to Ontario hospitals with a most responsible diagnosis of AMI (ICD-10 code (I21)) between April 1, 2007 and March 31, 2009 were included in the study. We established incident AMI cases by selecting only those patients for whom the absence of a hospitalization for AMI could be established for up fifteen years prior to the index AMI. Patients were required to be residents of Ontario for the duration of the study period to ensure that all services could be accurately tracked. Patients living in the Kingston/Quinte/Rideau region were excluded due to alternative billing arrangements in which services could not be captured with available data sources.

For each patient, a trajectory was established to measure the cost of key AMI-related services across a typical patient care continuum. The methodology for developing and presenting cost estimates was adapted from O'Brien et al. (2003) in which services across the care trajectory were reported separately for the event (hospitalizations associated with the patient's AMI and one-year follow-up heart-related readmissions) and for the post-state (community-based services following the AMI event). For the purposes of this study, a third pre-state phase was introduced to account for services associated with the patient's care prior to the AMI event. Cost estimates represented direct healthcare costs within the community and hospital settings.

## Longitudinal Patient Record

Longitudinal patient records were created using deterministic linkage via unique encrypted patient health insurance numbers. Ontario's DAD was used to estimate the cost of in-patient services associated with the AMI event, and all subsequent heart-related readmissions (ICD-10 I codes) for up to one year following the AMI index date. Patient records were linked with Ontario's Hospital Insurance Plan (OHIP) billing data to examine the costs of relevant pre-state and post-state services for three years prior to and three years following the AMI. This approach

resulted in a follow-up period of six years for each patient over a total study period ranging between the fiscal years of 2004 and 2012.

### Costing Data Sources and Costing Techniques

#### *CIHI's Discharge Abstract Database (DAD)*

In-hospital patient costs were generated using a bottom-up activity-based costing model to allocate costs for individual service recipients based on service dates (Chapko et al., 2009; CIHI, 2011b). To estimate event costs, Resource Intensity Weights (RIWTM) within the DAD were used to determine the intensity of hospital resource use for each patient based on the standard Canadian patient case-mix classification (Case Mix Groups, CMGTM). CMGs represent a standardized grouping of hospital services for a set of major clinical categories, similar to the diagnosis-related grouping (DRG) system used in the United States and in Europe (Hakkinen et al., 2012; Feter et al., 1980). RIWs reflect the relative value of hospital resources utilized for each inpatient case, including fixed and variable, direct and indirect costs attributable to inpatient care (CIHI, 2011b). Indirect costs associated with transient cost centres were allocated to cost centres using a reciprocal costing method - simultaneous equality allocation method (SEAM) (CIHI, 2011b; Young, 2003). Direct and indirect costs in each functional centre were then assigned to the patient based on an algorithm that accounted for unit costs and patient-specific workload (CIHI, 2011b). Canada's activity-based costing methods, and RIW and CMG standards have been documented elsewhere.(CIHI, 2004; CIHI, 2011b)

It should be noted that physician costs were not included in the standard RIW costing methodology as physician payments are handled outside of the hospital funding matrix in Canada. As such, physician billing costs which are handled largely on a fee-for-service basis in Ontario, Canada were directly allocated to relevant hospitalization event costs using the admission and discharge dates to develop complete event costs for each patient (Young, 2003). Individual RIWs for each discharge were multiplied against the 2008 average cost per weighted case for Ontario hospitals, to establish an in-hospital cost for each patient in the cohort (CIHI, 2013).

#### *Ontario's Health Insurance Plan Database (OHIP)*

OHIP billing data was used to measure of the cost of laboratory and diagnostic services and physician consultations associated with the pre-state, event, and post-state phases of care based on billing dates. Physician costs for targeted heart-related services provided in the community were measured using a defined set of OHIP fee and diagnostic codes, adapted from Tu et al.'s (2001) hospital-based methodology. Ontario's 2008 Schedule of Benefits was used to assign costs to each billed physician service and Ontario's laboratory unit index was used to directly allocate costs for laboratory services (OHIP, 1999).

#### *Ontario's Drug Benefits Database (ODB)*

The Ontario Drug Program provides prescription drug coverage for all Ontario residents aged 65 and over. ODB data were used to measure the cost of medications within the pre-state and post-state phases of care. Drug costs in the event phase were built into the RIW hospital costing methodology and could not be isolated for the purposes of comparison in this study. Cost estimates were generated for all prescriptions filled in the community for the following therapeutic drug classes; Statins, Beta Blockers, Calcium Channel Blockers and Ace-Inhibitors as per clinical practice guidelines (Tobe et al., 2011; Daskalopoulou et al., 2012; Anderson et al., 2013). Costs for prescription drugs were generated by multiplying the average cost per tablet by the quantity dispensed for each claim and directly allocated to each patient in the pre-state and post-state phases.

#### Demographic and Clinical Data Sources

Clinical co-morbidity data were derived from CIHI's DAD at the time of AMI admission based on the Ontario Acute Myocardial Mortality Prediction rules (Tu et al., 2001). Patient demographic data were derived from the ICES Registered Persons Database. Patients' urban/rural and socioeconomic status (SES) were determined using an area-based methodology in which the full patient postal code was linked with the 2006 Census neighbourhood data (Statistics Canada). Patients were assigned a low, medium and high SES based on median neighbourhood income that mapped to the Ontario income distribution.

## Statistical Analysis

Patient costs in the pre-state, event and post-state phases were calculated according to major spending categories. Cost per patient day survived was calculated by dividing the total spending in each phase of care by the total number of days contributed by each patient based on individual survival. As with most econometric data, cost distributions were heavily right-skewed, therefore both average and median patient costs are presented. To address non-normality, we used negative binomial regression to model the independent effects of socio-demographic and clinical co-morbidities on pre-state, event and post-state costs (Bond & Farewell, 2009; Charka et al., 2013). The over-dispersion parameter alpha in each model was significantly different from zero indicating that the negative binomial was a better fit to the data than the Poisson (Agresti, 2001). To address the high volume of zeros in pre and post-state costs, zero-inflated negative binomial regressions were applied (Lewsey & Thompson, 2004). Socio-demographic independent variables included age, sex, patient's urban/rural status and SES. Co-morbid independent variables included congestive heart failure (CHF), cardiac dysrhythmias, pulmonary edema, shock, chronic renal failure, acute renal failure, diabetes with complications, malignancy, and cerebrovascular disease (Tu et al., 2001). The regression models included an offset to address differences in log survival following discharge from hospital. Collinearity among predictor variables was determined to be acceptable based on a variance inflation factor cut-off of ten (Stevens, 1996). The Chi-Square Wald statistic was used to determine the contribution of the main effects, and incident rate ratios were used as the measure of association between groups. The study was approved by the Ottawa Hospital Research Ethics Board, Ottawa, Ontario, Canada.

## Results

### Patient Socio-demographic and Co-morbid Illness Characteristics

A total of 16,450 senior patients were included in the study cohort, with an average age of 79.7 at the time of the index AMI event. Patients' ages ranged from 65 to 105 across the six-year continuum of care period. Fifty-two percent of the sample was male and 14% lived in a rural area. The median personal income was \$27,681 dollars per annum. Among the co-morbid

illnesses diagnosed at the time of AMI, CHF (27%) and cardiac dysrhythmia (20%) were the two most common diagnoses (Table 1).

#### Crude and Survival Adjusted Pre-state, Event and Post State Costs

The crude average cost per patient for the six-year continuum of care was \$28,169 (Standard deviation (SD) 25,235) (Table 2). Of the total cost across the care continuum, 74% (\$20,794 (SD 24,221)) was associated with the in-patient event phase, 12% (\$3400 (SD 2910)) with the pre-state phase and 14% (\$3974 (SD 3397)) with the post-state phase in the community.

Table 3 delineates pre-state, event, and post-state cost per patient day adjusted by survival over the six-year follow up period. Once survival adjustments were applied, the cost per patient day of pre-state care was less than half (49%) of post-state care in the community (\$3.11 (SD 2.65)) per day versus \$6.32 (SD 14.39) per day). The average event cost per patient day in hospital (based on number of days in hospital) was \$1759 (SD 1047).

#### Socio-demographic and Clinical Predictors of Pre-State, Event and Post-State Costs

Table 4 presents results of the models examining socio-demographic and co-morbid illness predictors of pre-state, event, and post-state costs adjusted by the offset survival variable.

#### *Socio-demographic Cost Drivers*

Across each of the three models, patient's sex and location of residence were significant drivers of cost, when other factors were controlled for. Being male increased expected pre-state cost by 6.1% (95% Confidence Interval (CI) 1.03-1.09), event costs by 11.1%, (CI 1.08-1.14) and post-state costs by 4.6% (CI 1.02-1.08) in comparison to female patients. Living in an urban area increased patient's expected pre-state cost by 12.9% (CI 1.08-1.18), event costs by 5.9% (CI 1.02-1.09), and post-state costs by 11.8% (CI 1.08-1.16) compared to patient's living in a rural area. Patient's age was a negative predictor of event cost and post-state cost, decreasing expected costs by 0.7% (CI 0.991-0.995) and 3.6% (CI 0.966-0.970) respectively for each additional year. Patient's SES was not a significant predictor of pre-state or post-state cost, when all other factors were controlled for. However patient's low SES was a significant

predictor of in-hospital costs, increasing expected event costs by 3.5% (CI 1.00-1.07) in comparison to patients with high SES.

### *Co-morbid Illness Cost Drivers*

All co-morbid illnesses included in our models were significant predictors of cost in at least one of the pre-state, event or post-state phases, when other factors were controlled for. Co-morbid conditions grouped into two main types of cost drivers. One set of co-morbid illnesses were significant predictors of cost across the entire care continuum. These co-morbid illnesses, including CHF, shock, acute renal failure and cancers, were positive predictors of cost in the pre-state and event phases and then became negative predictors of cost in the post-state phase. For example, presence of CHF was a significant driver of pre-state cost (increasing costs by 30.9% (CI 1.26-1.36)) and of event costs (increasing costs by 60% (CI 1.56-1.64)). Correspondingly, presence of CHF decreased post-state costs by 5.5% (CI 0.91-0.98).

A second cost driver pattern was determined for cardiac dysrhythmias, cerebrovascular disease and chronic renal failure. These co-morbid illnesses were significant predictors of cost in the pre-state and event phases of care, but were not significant predictors of cost in the post-state event. For example, presence of cardiac dysrhythmias increased expected pre-state costs by 12.6% (CI 1.08-1.17), and increased expected event costs by 30.6% (CI 1.27-1.35), but did not significantly predict post-state costs.

### Discussion

This study provided a first-time population-based investigation of community and hospital costs related to AMI across a six-year care continuum for elderly patients in Ontario, Canada. The average healthcare cost per patient across the care continuum was found to be \$28,169 (SD 24,221) (2008 constant Canadian dollars). Average in-patient AMI cost for the first episode of care at \$14,684 (SD 19,174) was within range of other acute care costing studies conducted in the United States and Europe (Azoulay et al., 2003; Kauf et al., 2006; Tiemann, 2008; Hakkinen et al., 2012; Krumholz et al., 1998). However this study's novel approach to AMI costing across the care continuum demonstrated the substantial costs incurred beyond the acute care sector, by quantifying the community-based healthcare costs at 26% of the total patient cost across the six-

year care continuum. This work further demonstrated a two-fold increase in community-based costs from pre-state to post-state phases of care (\$3.11 (pre-state) versus \$6.32 (post-state) per patient day) when days survived were accounted for. Taken together these results highlight the substantial economic impact of AMI beyond the acute care sector and reinforce the value of taking a health system perspective to view health expenditures along a patient's continuum of care.

Accurate and comprehensive cost data are critical in economic evaluations in healthcare to assist decision makers in ensuring that limited resources are allocated as efficiently as possible (Evans & Crawford, 2000; Rice, 2000). Person-centric AMI cost estimates which span the different phases of the care trajectory through time are critical for the development of prevalence-based healthcare spending estimates and comprehensive cost of illness studies that may assist in future evaluation of care integration strategies for Canada's elderly (CDC, 2013; Rice & Miller, 1998). Person-centric cost estimates can be useful for developing cost-effectiveness studies in which net or incremental costs of care are considered in relation to patient outcomes (Noyes & Holloway, 2004). The cost estimates developed in this particular study which were based on net (not incremental) costs may be used to develop average cost-effectiveness ratios for non-competing choice cost analysis to determine an intuitive cost per unit of health gained (Bang & Zhoa, 2012).

The novel care continuum costing approach used in this study also identified key cost drivers at different phases of the care trajectory and raised a number of important questions for future research. In the hospital phase of care, our findings aligned with existing research in which the significant role of clinical co-morbidities in predicting AMI hospital costs has been demonstrated (Krumholz et al., 1998; Evans et al., 2007; Smolderen et al., 2010). By examining patient costs prior to the AMI event however, this study also pointed to clinical co-morbidities as significant cost drivers in the pre-state phase. In particular, presence of CHF, acute and chronic renal failure, and diabetes with complications had the largest impact on expected pre-state costs and expected event costs. These results may be indicative of continuity of care between community and acute care, in which high treatment intensity for patients with these conditions is occurring in both pre-state and event phases of care. Given that these co-morbid conditions have identifiable and modifiable risk factors that overlap with risk factors for AMI including obesity, hypertension, tobacco use, poor diet and sedentary lifestyles (Yusuf et al., 2001; WHO, 2003), it

is likely that pre-state care is focused on addressing this common set of precursive risk factors (Tobe et al., 2011). Further work exploring the relationship between pre-state and event spending is warranted to more fully elucidate the role of integrated care in the prevention, treatment and management of AMI.

In pursuit of the continuum of care perspective for AMI, we also examined cost-drivers in the post-event phase of care. In this phase we found that a number of co-morbid illnesses were significant negative predictors of post-state costs. Specifically, the presence of cancer, shock, acute renal failure, and CHF decreased expected post-state costs. While these results may appear unintuitive, they likely point to an important relationship between comorbid illness, survival and associated follow-up AMI costs that requires further investigation. We propose that these co-morbid illnesses were negative cost-drivers of post-state cost because of the high mortality rates associated with each condition (Tu et al., 2001). Despite the fact that survival differences were accounted for in the negative binomial model using a well-established offset method (Bond & Farewell, 2009; Charka et al., 2013), which assumes a linear cost accumulation trajectory, costs have been shown to accumulate over time as a non-linear step function (Evans et al., 2007). If an AMI patient with acute renal failure died one day following hospital discharge for example, the patient would not have sufficient time exposure to reach the next step function in treatment and corresponding costs within the community. In this scenario, acute renal failure would appear as a negative cost-driver for follow up post-state AMI care. This work highlights an important limitation within the existing literature and associated methods related to the time-varying non-linear nature of cost and its association with mortality outcomes at the patient level (Stargardt et al., 2013; McClellan et al., Schreyogg et al., 2010). Future research that applies novel methods that account for the time-varying nature of healthcare spending is required to more fully elucidate the relationship between co-morbid illness, mortality and the time-dependent nature of AMI healthcare costs at the patient level across the care continuum.

### Limitations

A number of limitations warrant consideration. First, the costs presented here necessarily underestimate complete healthcare costs in Canada for elderly AMI patients, as costs for home and long term care were not included in the analysis. Instead this study estimated costs based on

available data for the three largest categories of spending – hospitals, drugs and physicians (CIHI, 2004). Second, the use of administrative healthcare data allowed only for an examination of direct healthcare costs, rather than a summation of direct and indirect costs associated with total burden of disease. While indirect costs are useful for illustrating the impact of illness on society, direct costs can be equally informative for healthcare decision makers to illustrate opportunity costs for public healthcare resources utilized (Boccuzzi, 2003).

## Conclusions

As government healthcare agendas prioritize shifting trends in population aging and the corresponding impact on healthcare spending, there is an ever increasing need to fill the knowledge gap around AMI healthcare costs for the elderly along the continuum of care. This study provided a baseline analysis of the direct healthcare costs and cost drivers for AMI across a six-year care continuum in Ontario, Canada that will be critical for informing economic analysis and future decision making about integrated care for AMI among the elderly. The novel costing approach was also useful in identifying a number of new areas of inquiry related to cost drivers along the continuum of care and their role in generating health spending.

**Table 1 - Patient Characteristics of the AMI Cohort**

	Percentage %	N
<b>Socio-Demographic Characteristics</b>		
Average age at time of AMI event	79.7	16,450
Age range at time of AMI event	68-105	--
Age range for the full follow up period	65-103	--
Male Gender	51.9	8,535
Low Income (SES 1)**	44.4	7305
Medium Income (SES 2)**	37.7	6200
High Income (SES 3)**	17.9	2945
Median Income	27,681	--
Patients in rural residence	14.4	2376
<b>Co-morbidities*</b>		
Shock	3.5	573
Chronic Heart Failure	26.8	4415
Cancer	4.4	721
Cerebrovascular Disease	3.7	612
Pulmonary Edema	2.8	465
Acute Renal Failure	8.9	1459
Chronic Renal Failure	10.4	1696
Diabetes with Complications	1.1	182
Cardiac Dysrhythmias	20.1	3309

\*Co-morbid conditions based on Ontario AMI Mortality Prediction Rules, Tu et al., 2001.

\*\*Area based income methodology based on income distribution in the 2006 Ontario Census data from Statistics Canada. Neighborhood income quintiles were arranged such that the lowest two income groups formed the 'low-income' group, the third and fourth quintiles formed the 'middle-income' group, and the fifth quintile formed the 'high-income' group

Abbreviations: AMI (acute myocardial infarction), SES (socioeconomic status)

**Table 2 – Crude Average AMI Patient Pre and Post- Event, and State Costs across the Continuum of Care (2008 Constant Canadian Dollars)**

	PRE-STATE	HOSPITALIZATION EVENT		POST-STATE	TOTAL
	Pre-State Costs (Per Patient Cost for the 3 Years Prior to Index AMI Event)	Index AMI Event Costs Index Hospitalization (In-hospital drugs included in Hospital Cost)	One Year Follow-up Hospitalization Event Costs ( In-hospital drugs included in Hospital Cost)	Post State Costs (Per Patient Cost for the 3 Years Following Index AMI Event)	
<b>Physician fees</b>					
<b>Mean cost (SD)</b>	\$ 1234.05 (1554)	\$1777.74 (1785)	\$365.81 (903)	\$1707.31 (2105)	
<b>Median Cost (Inter-quartile range)</b>	\$656.57 (274-1606)	\$1377.13 (6427-14,628)	\$0 (0-0)	\$1008.36 (129-2500)	
<b>Drugs</b>					
<b>Mean Cost (SD)</b>	\$ 2166.45 (2020)	--NA--	--NA--	\$2266.83 (1913)	
<b>Median Cost (Inter-quartile range)</b>	\$ 1789.04 (282-3440)			\$2283.23 (249-3669)	
<b>Hospital</b>					
<b>Mean cost (SD)</b>	--NA--	\$14,684.77 (19,174)	\$3966.02 (12,868)	--NA--	
<b>Median Cost (Inter-quartile range)</b>		\$9779.97 (609-2157)	\$0 (0-390)		
<b>Sub-total</b>					
<b>Mean cost (SD)</b>	\$3400.50 (2910)	\$16,462.21 (20,457)	\$4331.83 (13,382)	\$3974.14 (3397)	
<b>Median Cost (Inter-quartile range)</b>	\$2806.69 (1019-5041)	\$10,656.24 (7365-16,520)	\$0 (0-1325)	\$3858.33 (612-6091)	
<b>TOTAL</b>					
<b>% Total Cost</b>	12.07%	73.82%		14.11%	
<b>Mean Cost (SD)</b>	\$3400.50 (2910)	\$20,794.04 (24,221)		\$3974.14 (3397)	\$28,168.67 (25,235)
<b>Median Cost (Inter-quartile range)</b>	\$2806.69 (1019-5041)	\$13,454.72 (8719-24,466)		\$3858.33 (612-6091)	\$21,549.90 (14,949-33,178)

Abbreviations: AMI (acute myocardial infarction), SD (standard deviation), NA (not available)

**Table 3 – AMI Community and Hospital Healthcare Cost per Patient Day Survived (2008 Constant Canadian Dollars)**

	PRE-STATE	HOSPITALIZATION EVENT	POST-STATE
	Primary Care Cost for AMI Care per patient day in community	Hospitalization Events for AMI care per patient day in hospital	Primary Care Cost for AMI Care per Patient Day in Community
Mean Cost per day (SD)	\$3.11 (2.65)	\$1,758.58 (1047)	\$6.32 (14.39)
Median Cost per day	\$2.56	\$1497.77	\$4.67

Abbreviations: AMI (acute myocardial infarction), SD (standard deviation), NA (not available)

Table 4 - Cost Drivers of Care for Pre-State, Event and Post-State Costs

	PRE-STATE			HOSPITALIZATION EVENT			POST-STATE		
	RR	95%CI	p-val	RR	95%CI	p-val	RR	95%CI	p-val
Socio-Demographic Characteristics									
<b>Age</b>	1.000	-ns-	-ns-	0.993	0.991-0.995	<.0001	0.968	0.966-0.970	<.0001
<b>Sex (Male)</b>	1.061	1.027-1.095	0.0003	1.111	1.085-1.138	<.0001	1.046	1.017-1.076	0.0017
<b>Urban Patient Residence</b>	1.129	1.079-1.180	<.0001	1.059	1.025-1.095	0.0007	1.118	1.075-1.162	<.0001
<b>SES Low vs High*</b>	1.026	-ns-	-ns-	1.035	1.002-1.070	0.0379	0.986	-ns-	-ns-
<b>SES Mid vs High*</b>	1.029	-ns-	-ns-	1.019	-ns-	-ns-	0.983	-ns-	-ns-
Co-Morbid Illnesses at time of AMI Hospitalization**									
<b>Shock</b>	1.317	1.207-1.437	<.0001	1.356	1.271-1.446	<.0001	0.839	0.751-0.936	0.0017
<b>Chronic Heart Failure</b>	1.309	1.262-1.358	<.0001	1.600	1.557-1.645	<.0001	0.945	0.914-0.977	0.0008
<b>Cancer</b>	1.199	1.111-1.295	<.0001	1.119	1.057-1.185	0.0001	0.698	0.650-0.751	<.0001
<b>Cerebrovascular Disease</b>	1.214	1.117-1.320	<.0001	1.387	1.304-1.475	<.0001	0.928	-ns-	-ns-
<b>Pulmonary Edema</b>	1.046	-ns-	-ns-	1.181	1.099-1.269	<.0001	1.057	-ns-	-ns-
<b>Acute Renal Failure</b>	1.198	1.132-1.269	<.0001	1.409	1.350-1.470	<.0001	0.901	0.851-0.954	0.0004
<b>Chronic Renal Failure</b>	1.446	1.372-1.525	<.0001	1.204	1.157-1.252	<.0001	1.023	-ns-	-ns-
<b>Diabetes with Complications</b>	1.528	1.317-1.774	<.0001	1.426	1.275-1.596	<.0001	0.943	-ns-	-ns-
<b>Cardiac Dysrhythmias</b>	1.126	1.082-1.171	<.0001	1.306	1.268-1.345	<.0001	1.034	-ns	-ns-

\*Area based income methodology based on income distribution in the 2006 Ontario Census data from Statistics Canada. Neighborhood income quintiles were arranged such that the lowest two income groups formed the 'low-income' group, the third and fourth quintiles formed the 'middle-income' group, and the fifth quintile formed the 'high-income' group

\*\*Co-morbid conditions based on Ontario AMI Mortality Prediction Rules, Tu et al., 2001.

Abbreviations: AMI (acute myocardial infarction), SES (socioeconomic status), ns (not significant), RR (incident rate ratio), 95%CI (95 percent confidence interval)

## Chapter 3 - References

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## Chapter 4

**Full title:** Does Higher Hospital Spending Improve Survival Outcomes for Myocardial Infarction? Examining the Cost-Outcomes Relationship using Time-Varying Covariates

**Short Title:** AMI Costs and Outcomes Using Time Varying Covariates

**Authors:**

Deborah Cohen, PhD Candidate, Department of Population Health, University of Ottawa, Institute for Clinical Evaluative Sciences, Ontario, Canada

Douglas G Manuel, MD, FRCPC, MSc, Ottawa Hospital Research Institute, University of Ottawa, Institute for Clinical Evaluative Sciences, Ontario, Canada

Peter Tugwell, MD, FRCPC, MSc, Centre for Global Health, Institute of Population Health, Ottawa Health Research Institute, University of Ottawa, Ontario, Canada

Claudia Sanmartin, PhD, Health Analysis Division, Statistics Canada, Ontario, Canada

Tim Ramsay, PhD, Ottawa Hospital Research Institute, Department of Epidemiology and Community Medicine, University of Ottawa, Ontario, Canada

**Corresponding Author:** Deborah Cohen

## Abstract

**Objectives:** Previous research on acute myocardial infarction (AMI) has found that higher hospital spending is associated with improved survival at the patient level, however this cost-outcomes research did not account for survivor-treatment selection bias. The purpose of this study was to examine the AMI cost-outcome relationship taking into account survivor-treatment selection bias.

**Data Sources:** Canadian Institute for Health Information Discharge Abstract data were used track costs for AMI hospitalizations. Ontario Vital Statistics data were used to track patient mortality.

**Study Design:** A standard Cox survival model was compared to an extended Cox model using hospital costs as a time-varying covariate, to examine the impact of cost on one-year survival in a cohort of 30,939 first-time AMI patients in Ontario, Canada from 2007 to 2010.

**Principle Findings:** In both models, higher spending decreased the hazard of dying, however the size of the protective effect was overestimated by 62% when survivor-treatment bias was not adjusted for.

**Conclusion:** Cost-outcomes research for AMI can overstate the protective effect of higher spending on survival if survivor-treatment bias is overlooked. These results point to a methodological issue that has important policy implications for AMI and potentially for healthcare cost-outcomes research in general.

**Keywords:** Myocardial Infarction, time-varying covariates, cost-outcome relationships, survivor-treatment selection bias

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## Does Higher Hospital Spending Improve Survival Outcomes for Myocardial Infarction?

### Examining the Cost-Outcomes Relationship using Time-Varying Covariates

For decades, policy makers around the world have grappled with the question of value for money in healthcare (Snowdon et al., 2012; Sorenson et al, 2008). Does higher healthcare spending result in better patient outcomes? Decades of rising health expenditures in most industrialized countries have reinforced efforts to reduce costs while maximizing patient outcomes for many disease conditions (OECD, 2013). Even in Canada's universal healthcare context, in which health spending is publicly financed and not subject to profit-driven market forces, the relationship between costs and outcomes and the corresponding return on investment is a priority policy issue for Canadian governments and clinicians alike (Blomqvist & Busby, 2012; Health Council of Canada, 2009).

Conducting cost-outcomes research at the patient level is challenging due to the observational nature of most study designs. Because it is often not practical or ethical to randomize patients to higher or lower cost treatment groups, researchers must address treatment selection bias – a form of bias in which systematic differences in patient baseline characteristics between different treatment groups can mask the true effect of the treatment on the outcome (Stukel et al., 2007). This form of bias is typically addressed through a variety of statistical methods in which observable or unobservable confounders are controlled for in the treatment-outcome model. Traditionally, epidemiological outcomes research has employed methods such as multivariate model risk adjustment and propensity score matching to account for observable differences in case-mix amongst patients with different treatment intensities (Desai et al., 2009; Stukel et al., 2007; Ording & Soreson, 2013). Instrumental variables analysis has been used predominantly among economists to address the unobservable heterogeneity amongst patients when studying the relationship between costs and outcomes (McClellan et al., 1994; Newhouse & McClellan, 1998; Schreyogg & Stargardt, 2010; Stargardt, Schreyogg & Kondofersky, 2013). These well established methodological approaches adjust for traditional forms of treatment selection bias, however they fail to address a second form of treatment selection bias related to the time dependent nature of cost and its impact on survival.

This second form of bias called 'survivor-treatment selection bias' is often overlooked in outcomes research (van Walraven et al., 2004; Glesby & Hoover, 1996). Survivor-treatment

selection bias, also known as ‘time-dependent bias’ occurs in survival analyses when the timing of the medical treatment in relation to survival is not accounted for. Patients who live longer and who may be healthier than patients who die early, are also more likely to receive treatment. In this context, an ineffective treatment can appear erroneously to improve survival simply because healthier patients live long enough to receive treatment (Glesby & Hoover, 1996). We argue that this form of bias extends beyond treatment-outcome studies to research focused on the relationship between costs and outcomes, because the longer a patient is available to receive treatment, the greater the corresponding likelihood for increased costs. Patients who are hospitalized for a particular disease condition for example, may be ‘low-cost’ users simply because they die soon after admission, while patients may become high-cost users as a result of having survived long enough to achieve ‘high-cost’ status. Furthermore, any hospital readmissions that occur as sequelae of the index event, will add additional patient costs that must be accounted for, but only for those patients who survive the initial episode of hospital care. Without adjusting for the time dependent nature of cost, research may overstate the importance of higher spending in relation to survival.

The relationship between cost and outcomes for acute myocardial infarction (AMI) provides a useful case study to assess the potential impact of survivor-treatment selection bias. AMI is an acute condition requiring immediate hospitalization and has a well established care trajectory in which patient costs accumulate over time (Hassan et al., 2010). As the leading cause of death in Canada, AMI represents one of the greatest burdens to the Canadian healthcare system, costing over 500 million dollars and requiring over 50,000 patient hospitalizations annually (Kolansky, 2009; Tu et al., 2009). Previous research that has examined AMI hospital costs and patient outcomes using traditional epidemiological and economic methods, has generally reported a relationship between higher spending and improved patient survival, however this relationship may be overstated because previous research did not account for survivor-treatment selection bias (Stukel et al., 2012; Schreyogg & Stargardt, 2010; Stargardt, Schreyogg & Kondofersky, 2013). To assess the potential impact of survivor-treatment selection bias on AMI costs and outcomes, we compared a traditional Cox proportional hazard survival model to an extended Cox survival model in which hospital costs were treated as time-varying covariates (Therneau & Grambsch, 2000). This study posed the following two research questions. First, does increased hospital spending improve survival outcomes for AMI patients when survivor-treatment bias is

accounted for? And second, to what extent does the time-varying nature of hospital spending affect the size of the apparent relationship between AMI costs and outcomes? We believe this study represents the first application of the time-varying extended Cox methodology to address the temporal nature of cost in relation to AMI survival.

## Methods

All patients between the ages of 40 and 105 years of age, admitted to Ontario hospitals with a most responsible diagnosis of AMI (ICD-10 code (I21)) between April 1, 2007 and March 31, 2009, were included in the cohort. Incident AMI cases were established by examining previous hospital discharge records for up to 15 years prior to the index AMI event. Patients were required to be residents of Ontario for the duration of the study period to ensure that all services could be accurately tracked. Patients living in the Kingston/Quinte/Rideau region were excluded due to alternative billing arrangements in which services could not be captured with available data sources.

Encrypted patient health insurance numbers were used to link patient hospital records with the Ontario's Registered Persons Database to establish date of death for up to one year following the index AMI admission. The complete follow-up period for the study ranged between April 1, 2007 to March 31, 2010.

## Data Sources

Total hospital spending for the index AMI episode of care and one-year AMI hospital readmissions were studied in a cohort of 30,939 first-time AMI patients in Ontario, Canada. Hospital costs represented all inpatient services including nursing and allied health staffing, diagnostics and procedures and pharmaceuticals. Resource Intensity Weights in the Canadian Institute for Health Information (CIHI) Discharge Abstract Database were used to determine the intensity of hospital resource use based on standard Canadian case-mix classification groups (CIHI, 2004). The RIW was multiplied against the 2008 average cost per weighted case for Ontario hospitals to establish a total in-hospital cost for each patient for each episode of care (CIHI, 2013). Physician billing costs from Ontario's Hospital Insurance Plan database, which are not included as part of the RIW, were added to the hospital cost for each patient based on billing dates that corresponded to admission and discharge dates for the AMI hospitalization and

subsequent readmissions within one year for any ICD-10 code I (cardiac-related disease classification). Details of the costing methodology have been documented elsewhere (Cohen et al., 2014). Patient's urban/rural status and socioeconomic status (SES) were determined using an area-based methodology in which the full patient postal code was linked with the 2006 Census neighbourhood data from Statistics Canada.

### Survival Models

A standard Cox survival model was compared to an extended Cox survival model to examine the time-varying nature of AMI hospital costs on patient mortality over one year. In both models, the outcome variable was all-cause mortality. Costing data were log transformed using the natural log to adjust for heavy right skewness in the distribution (Dierh et al., 1999). In the standard Cox model the time-varying nature of cost was not accounted for and total costs were assigned to each patient at baseline. In the extended Cox survival model, the time-varying nature of cost was modelled by allowing a patient's costs to change with time as costs were accrued for each hospitalization. Other covariates in the model included patient characteristics (including age, sex, patient's urban/rural status, and socioeconomic status), patient co-morbidities (including diabetes with complications, cerebrovascular disease, coronary heart failure, acute renal failure, chronic renal failure, pulmonary edema, malignancies, shock and cardiac dysrhythmia as per the Ontario Mortality Prediction Rules (Tu et al., 2001), infarct information (including ST segment elevation (STEMI), non-STEMI, and unknown), hospital characteristics (including AMI patient volumes and teaching hospital status), and year of index AMI.

All covariates were included in both models for the purposes of comparison. To correct for independence among patients treated within the same hospital, a hospital identifier was included as a robust variance estimator in both the standard and extended Cox models (Allison, 2010). Collinearity among predictor variables was determined to be acceptable based on a variance inflation factor cut-off of ten (Stevens, 1996). The Wald Chi-square test was used to examine the overall fit of each model as well as the significance of beta coefficients for each covariate in the model. Hazard ratios (HR) were used to express the instantaneous risk of events associated with each covariate in the model, when other covariates were controlled for.

To assist with interpretation of the log transformed costs in both models, baseline survival functions were calculated for a typical male patient, aged 69 with no associated co-morbidities, with a ‘low-cost’ level of spending (25<sup>th</sup> percentile of the cost distribution (\$8,699)) compared with a ‘high-cost’ level of spending (75<sup>th</sup> percentile of the cost distribution (\$23,742)). In our data, the difference in spending between a patient at low and high-cost level of spending at the 25<sup>th</sup> and 75<sup>th</sup> percentiles approximated a one unit increase in log-cost (25<sup>th</sup> percentile log-cost 9.071, 75<sup>th</sup> percentile log-cost 10.075). The difference in survival between the low and high-cost user were calculated using both the standard and extended Cox survival models when all other variables in the model were held constant, in order to demonstrate the impact of survivor-treatment selection bias in a practical patient example.

#### Technical details of the extended Cox model

In the extended Cox model, each patient was assigned a baseline cost of 0 (log cost 1) at the beginning of the index AMI admission. A new patient cost was assigned on the date of discharge from hospital based on the Resource Intensity Weight associated with that episode of care. If a patient was readmitted to hospital a second time, the patient was assigned a new cost on the date of discharge for that hospitalization. Patient costs were accrued across time for every hospital readmission, assigning a new patient cost as an increasing step function based on each subsequent date of discharge. Costs were recorded at irregular intervals using the counting process in SAS 9.2 for Proc PHREG with a new patient cost delineated in a new patient record for each new start and stop time frame (Allison, 2010).

In the extended Cox model, cost and survival were allowed to co-vary with time on either side of the regression equation. Risk of death was calculated within risk sets for each event time, based on a patient’s time-specific cost. The basic patient level statistical model was as follows:

$$\log h_i(t) = \alpha(t) + \beta_1 \cdot X_1(t) + \beta_{2-18} \cdot X_{2-18}$$

Where  $\log h(t)$  was the instantaneous hazard for mortality at time  $t$  following the AMI event, given  $\alpha(t)$  the baseline hazard when all covariates were zero, the time-varying covariate log cost ( $X_1(t)$ ), and all other static variables ( $X_{2-18}$ ) whose values were fixed at baseline.

To examine the effect of non-proportionality among all variables in the model other than cost, we ran a sensitivity analysis to allow each non-proportional covariate to interact with time. Also, we ran sensitivity analyses on the baseline model to examine the cost-outcome relationship for a female person at age 55 and 75, as well as for a person with multiple co-morbid illnesses according to the Ontario Mortality Prediction Rules (Tu et al., 2001). There were no substantial changes to the relationship between AMI costs and outcome in any of the models. The study was approved by the Ottawa Hospital Research Ethics Board, Ottawa, Ontario, Canada. All analyses were carried out using SAS version 9.2.

## Results

Table 1 presents the patient and hospital characteristics for the cohort studied, and one-year follow up costs. A total of 30,939 patients were included in the study cohort, with an average age of 69 at the time of the index AMI event. Rates of comorbid illness and infarct status for AMI patients were consistent with previous estimates. The median patient cost for a one year follow up period was \$13,363 in 2008 constant dollars (Interquartile Range (IR) 15,060). Table 2 presents patient mortality rates, patient hospitalization information, and number of readmissions within the AMI cohort. Within one year, 19% of the patients in the cohort died, and 34% of the patients had been readmitted at least once.

Table 3 presents results of both standard and extended Cox regression models. In both models, age was a significant predictor of survival outcomes (increasing hazard of death by 6% for every year aged) (extended Cox HR 1.064 (95% confidence interval CI (1.061-1.067))), as were all comorbid illnesses with the exception of pulmonary edema. In both models, the presence of shock was the strongest predictor of death with more than a six-time increase in risk of death (extended Cox HR 6.147 (95% CI (5.423-6.968))), followed by malignancies with two-and-a-half-time increase in risk of death (extended Cox HR 2.498 (95% CI (2.241-2.784))), and acute renal failure with just less than a two-time increase in risk of death (extended Cox HR 1.966 (95% CI (1.775-2.178))).

In both models, higher spending decreased the hazard of dying, however the size of the effect was overestimated when the time-varying nature of cost was not adjusted for. In the extended Cox model which adjusted for survivor-treatment bias, a one unit increase in log-cost was

associated with a 30% decrease in the hazard of dying (HR 0.700 (95% CI (0.645-0.758)). However, in a standard Cox model the same expenditure was associated with a 49% decrease in the hazard of dying (HR 0.513 (95% CI (0.479-0.549)). This represents a 62% overestimation of the benefit of higher spending, almost two-thirds of the total effect, when survivor-treatment bias was not taken into account, thus demonstrating the sizeable impact of survivor-treatment bias on the AMI cost-outcomes relationship.

We used a baseline analysis to approximate a tangible one unit increase in log cost to calculate the difference in survival curves between a low and high cost user (25<sup>th</sup> and 75<sup>th</sup> percentile costs (\$8,699 and \$23,742))(Allison, 2010). By comparing the one year survival differences between the standard and extended Cox models, the impact of survivor-treatment selection bias could be demonstrated. Figure 1 presents the difference in predicted one-year survival between a patient at low and high-cost spending levels at the 25<sup>th</sup> and 75<sup>th</sup> percentiles of the cost distribution, using the two different survival methods. In this baseline example, survival curves were estimated for a male AMI patient, aged 69, with no other associated co-morbidities. Using the extended Cox model, an increase in cost from \$8,699 to \$23,742 improved the patients expected one year survival by 3.0%. However, using the standard Cox model, an increase in cost from \$8699 to \$23,742 improved the patients expected one-year survival by 5.3%. According to the baseline analysis for this particular AMI patient, the protective effect of hospital cost on survival was overestimated by 76% when survivor-treatment bias was not accounted for, an overestimation even larger than the two-thirds found in the full model.

## Discussion

The goal of this study was to examine the relationship between hospital costs and AMI outcomes while addressing survivor-treatment bias by modelling cost as a time-varying covariate. We observed a significant relationship between increased hospital spending and decreased mortality in a cohort of AMI patients in Ontario, Canada between the years of 2007 and 2010. However the size of the protective effect of hospital spending was overestimated when hospital costs were modelled as a time-invariant covariate in a standard Cox survival model. In the standard model, a one unit increase in log-cost decreased the hazard of dying by 49% as compared to only 30% in the extended Cox survival model. By failing to account for the survivor-treatment bias in this study, the relationship between costs and AMI outcomes was overestimated by 62% -

approximately two-thirds of the total treatment effect. This finding suggests that if survivor-treatment bias is overlooked, future research examining the relationship between AMI costs and outcomes may materially overstate the protective effect of spending on patient outcomes.

To assist with the interpretation of a one unit increase in log-costs, we opted to model a patient scenario in which survival was predicted based on a difference in spending that approximated a one unit increase in log-cost, while other patient factors were held constant. The purpose of this baseline analysis was to demonstrate in an intuitive patient example, the impact of survivor-treatment bias by comparing the two survival methods. In our data, a one unit increase in log-cost translated most intuitively to the difference in spending at the 25<sup>th</sup> and 75<sup>th</sup> percentile of the cost distribution (\$8,699 for a low cost user and \$23,742 for a high cost user). Using the standard Cox method, a patient who had a cost of \$23,742 (high cost user) would have a 5.3% higher expected one-year survival than a patient with a cost of \$8,699 (low cost user). However, using the extended Cox method, a high cost user's improvement in one-year expected survival was only 3.0% when compared with a low cost user. By comparing the predictive survival models for the two methods, Figure 1 demonstrates an overestimation of the protective effect of AMI costs on survival by more than two-thirds for a male patient, aged 69 with no associated co-morbidities, when survivor-treatment selection bias was not accounted for. According to sensitivity analysis for other patient scenarios in which the patient was modelled with alternative age, sex, and/or differing co-morbid conditions, the predicted survival curves and treatment effect sizes did vary. However the general pattern of results remained the same across each scenario modelled - the size of the protective effect was overstated when survivor-treatment bias was not accounted for. The present study results are consistent with a small but growing body of research that has examined the impact of survivor-treatment selection bias in survival analysis studies in healthcare (Austin et al., 2006; Sy et al., 2009). A systematic review in 2006 found that more than 60% of outcome studies in leading healthcare journals were susceptible to survivor-treatment selection bias, and that this bias had the potential to alter respective study conclusions in more than half of the studies affected (Austin et al., 2006).

Our study builds upon existing research that has demonstrated a significant relationship between hospital spending and improved patient survival for AMI. Previous studies used traditional epidemiological and economic methodological techniques to address selection bias, however the

time varying nature of cost was not addressed, raising key questions about the way that survivor-treatment selection bias may have influenced results. We believe the present study represents the first to address the potential for survivor-treatment bias for AMI costs on survival outcomes. By using an extended Cox survival model to examine cost as a time-varying covariate, this study demonstrated the marked reduction in the importance of the relationship between costs and AMI outcomes, when survivor-treatment selection bias was accounted for. The findings of the present study may have important policy implications, suggesting that while higher AMI costs are associated with improved health outcomes, the strength of the relationship may not be as substantial as previous research suggests. The present results also raise concerns about the potential overestimation of the protective effect of costs on survival outcomes within the general healthcare cost-outcomes literature. Future research is required to examine the impact of survivor-treatment bias on cost-outcomes research for other acute and chronic disease conditions.

It is important to note that we do not propose the time-varying methodology as a replacement for, or superior to, traditional methods used to address general treatment selection bias in observational cost/outcomes health research. Instead it is proposed as a complementary method to account for survivor-treatment selection bias which can have meaningful impacts on results. The instrumental variables methodology in particular, holds considerable promise in cost-outcomes research (Stukel et al., 2007; Rassen et al., 2009) in that it goes beyond traditional epidemiological methods to address unobservable heterogeneity in the data. This technique is particularly relevant for healthcare outcomes research given that the majority of data sources are administrative in nature and patient records often lack sufficient clinical detail and refined patient characteristic information to fully adjust for all potential confounding (Ayanian, 1999). However standard instrumental variables techniques fail to deal well with time-varying covariates and corresponding survivor-treatment selection bias (Hernan & Robins, 2006). The development of new research methods which combine the advantages of time-varying covariates and instrumental variables within survival analysis will likely yield the most robust estimates to study the relationship between costs and outcomes, however to our knowledge no such methodology is yet available. This study encourages support for the development of such new methods that can simultaneously address traditional and time-dependent treatment selection bias in outcomes research.

This study has several limitations that warrant consideration. First, the Resource Intensity Weights (CIHI, 2004) used to calculate per patient hospital costs represents a relative value measuring total patient resource use in relation to an average typical acute care inpatient. As such, patient costs in this study represented an averaged value, depending upon the services received and case-mix classification assigned, rather than a precise individualized cost estimate. This may have reduced costing variability amongst patients in the cohort. To address this issue, patient specific physician billing fees were added to each patient's total cost based on hospital admission and discharge dates to enrich the costing data with a greater level of granularity.

Second, costing data are notoriously difficult to model given the heavy right-tailed skewness in the distribution. Consequently, interpretation of costing data requires careful consideration depending upon which end of the tail one considers. A \$1000 increase in cost at the lower end of the distribution for example, can be substantially more impactful than a \$1000 increase at the higher end. As a result, general statements about cost increases across the distribution cannot be interpreted in a linear fashion. In our study, hospital costs were log transformed to address the heavy skewness, however the authors acknowledge that log-costs are challenging to interpret. We opted not to retransform logged results because of the risk of introducing new bias associated with the log transformed geometric mean (Baser, 2007). Instead, to assist the reader's interpretation of the effect of hospital cost on AMI survival outcomes, Figure 1 was used to model the differences in survival at the 25<sup>th</sup> and 75<sup>th</sup> percentile for a typical patient in order to approximate a one unit increase in log cost. These cut points were used only as an example and should not be considered predictive models in their own right (Fisher & Lin, 1999). Instead this tangible patient example was selected to approximate the effect of increase spending (from low to high cost) on survival, in order to inform the health policy dialogue that contemplates the cost-outcomes relationship for healthcare in Canada. The non-linear nature of cost data is a challenge for most cost-outcomes research. A number of approaches have been developed to address this challenge however each approach has its own unique limitations with respect to bias and meaningful interpretation (Baser, 2007; Briggs & Gray, 1998; Diehr, 1999). Continued work to advance this field and to assist with meaningful interpretation of heavily right skewed cost data are called for in order to clarify the literature for healthcare policy makers and researchers alike.

## Conclusion

By examining the relationship between spending and survival for AMI patients in Ontario, Canada, this study addressed a key methodological issue that has important health policy implications. Results from this work align with previous research demonstrating a relationship between higher hospital spending and decreased patient mortality for AMI, however our work demonstrated a substantial overestimation of the size of the protective effect between cost and outcome when survivor-treatment bias was not accounted for. Without addressing this form of time-dependent bias, which has traditionally been overlooked in previous research, it is likely that research will unintentionally overstate the importance of AMI costs in relation to survival outcomes. This work may also point to survivor-treatment selection bias as a significant source of bias in other healthcare cost-outcomes research. Future work exploring the time-varying nature of costs and outcomes for other disease conditions is warranted.

Table 1 – Characteristics of the Study Cohort

<b>Patient Characteristics</b>	%	N
<b>Total AMI Patient Sample</b>		30,939
Mean Age (SD)	68.6 (13.9)	
Sex (% female)	37.32	11,546
Patient Residence (% rural)	14.36	4,444
SES* - Low	43.75	13,535
SES – Medium	38.30	11,851
SES – High	17.95	5,553
<b>Patient Co-morbidities**</b>		
Diabetes with complications	0.91	282
Cerebrovascular disease	2.58	798
Coronary heart failure	18.28	5,657
Acute Renal Failure	5.73	1,774
Chronic Renal Failure	6.81	2,106
Pulmonary Edema	2.12	656
Malignancies	3.09	956
Shock	2.95	912
Cardiac Dysrhythmia	14.55	4,503
<b>Infarct Information</b>		
Stemi	29.50	9,128
Non-stemi	54.86	16,973
Unknown	15.64	4,838
<b>Hospital Characteristics</b>		
<b>Total Number of Hospitals</b>		162
Mean number of AMI cases (SD)	327 (389)	
Teaching Hospital	7.44	12
<b>Year of Index AMI Hospitalization</b>		
2007	36.68	11,349
2008	51.20	15,846
2009	12.12	3,750
<b>One-Year Follow Up Costs</b>		
	Mean	SD/IR
Mean actual costs	20,741	SD 24,012
Median actual costs	13,363	IR 8,699-23,742
Median Log cost	9.500	IR 9.071-10.076
25 <sup>th</sup> Percentile cost	8,699	
75 <sup>th</sup> Percentile cost	23,742	

\* Area-based income methodology used based on income distribution in the 2006 Ontario Census data from Statistics Canada

\*\*Co-morbid illnesses based on Ontario Acute Mortality Prediction Rules (Tu et al., 2001)

SD (Standard Deviation), IR (Interquartile range), STEMI (ST segment elevation myocardial infarction), AMI (acute myocardial infarction)

Table 2 – Mortality and Hospital Admission Rates

Patient Mortality Rates	%	N
<b>7 day</b>	6.83	2,112
<b>30 day</b>	10.64	3,292
<b>90 day</b>	13.60	4,208
<b>365 days</b>	19.15	5,924
Patient Hospitalization Information	Mean/Median	SD/IR
<b>LOS in days for first episode of care (mean/SD)</b>	6.50	(10.05)
<b>LOS in days for first episode of care (median/IR)</b>	4.0	(2-7)
<b>Total hospital days within one year (mean/SD)</b>	10.78	(15.24)
<b>Total hospital days within one year (median/IR)</b>	6.0	(4-12)
<b>Number of discharges range</b>	(1-11)	
Patient Readmission Information	%	N
<b>0 Readmissions</b>	65.80	20,358
<b>1 Readmission</b>	19.72	6,101
<b>2 Readmissions</b>	7.96	2,463
<b>3 or more Readmissions</b>	6.52	2,017

IR (Interquartile Range), LOS (Length of Stay), Episode of Care represents the complete set of consecutive hospitalizations for the first acute myocardial infarction hospitalization

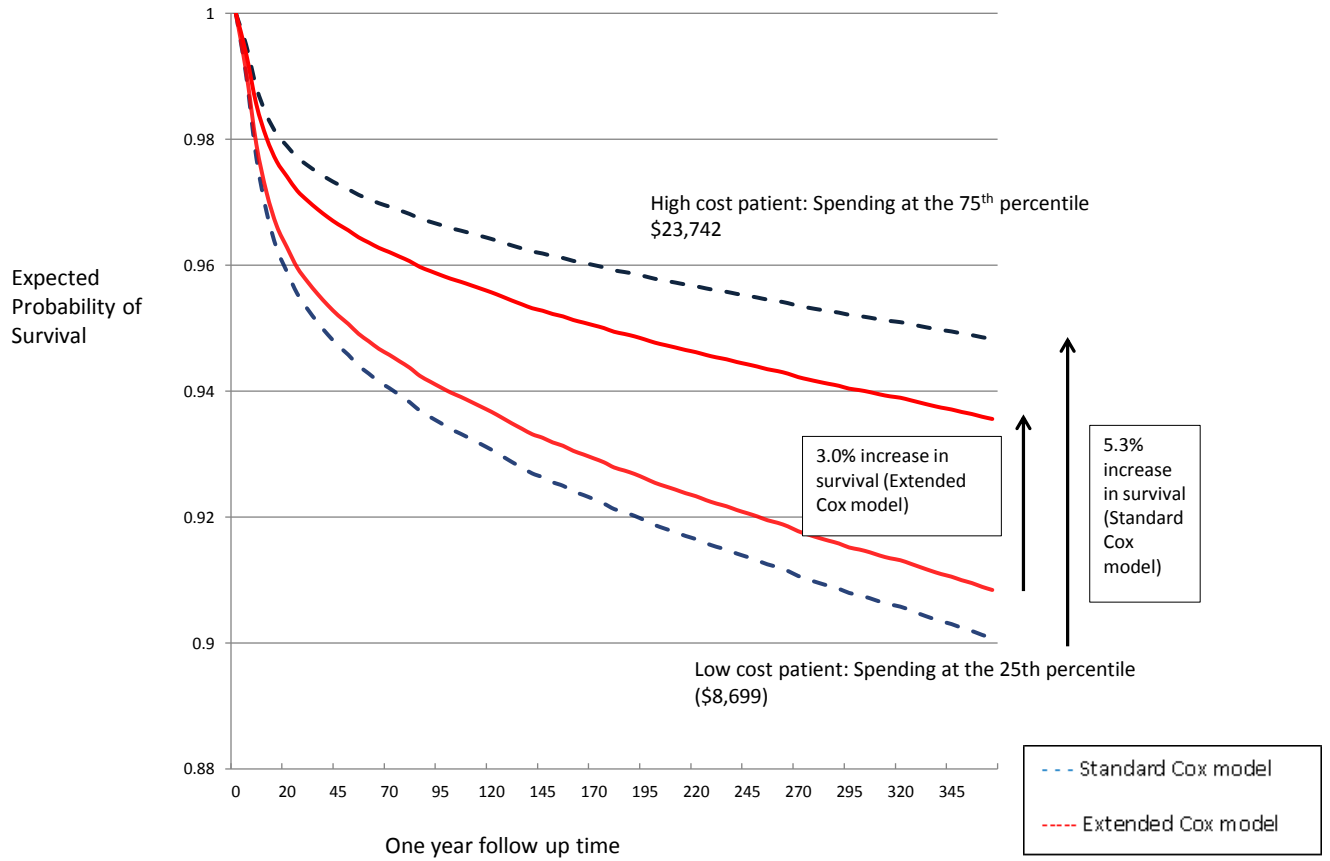
AMI Care, Costs, Outcomes and Equity

Table 3 – Results of Standard and Extended Cox Survival Model - Examining the Relationship between Log Costs and Survival Outcomes

	Standard Cox Model (Time-Invariant)			Extended Cox Model (Time-Varying)		
	Hazard Ratio	95%CI	p-value	Hazard Ratio	95% CI	p-value
<b>Log Cost</b>	0.513	0.479-0.549	<.0001	0.700	0.645-0.758	<.0001
<b>Age</b>	1.061	1.058-1.064	<.0001	1.064	1.061-1.067	<.0001
<b>Sex (M v F)</b>	1.077	1.007-1.152	0.029	1.053	0.984-1.127	0.135
<b>Rural patient</b>	1.061	0.972-1.158	0.187	1.080	0.993-1.175	0.074
<b>SES( low v high)</b>	1.103	1.013-1.203	0.024	1.077	0.989-1.173	0.087
<b>SES (mid v high)</b>	1.077	0.992-1.168	0.076	1.060	0.978-1.148	0.156
<b>Diabetes with complications</b>	1.606	1.303-1.978	<.0001	1.455	1.189-1.781	0.0003
<b>Cerebrovascular disease</b>	1.930	1.693-2.199	<.0001	1.800	1.577-2.054	<.0001
<b>Coronary heart failure</b>	2.092	1.961-2.232	<.0001	1.812	1.696-1.935	<.0001
<b>Acute Renal Failure</b>	2.145	1.936-2.376	<.0001	1.966	1.775-2.178	<.0001
<b>Chronic Renal Failure</b>	1.259	1.127-1.406	<.0001	1.189	1.067-1.325	0.0017
<b>Pulmonary Edema</b>	1.116	0.951-1.310	0.178	1.032	0.881-1.210	0.693
<b>Malignancies</b>	2.535	2.279-2.819	<.0001	2.498	2.241-2.784	<.0001
<b>Shock</b>	6.521	5.757-7.387	<.0001	6.147	5.423-6.968	<.0001
<b>Cardiac Dysrhythmia</b>	1.163	1.081-1.252	<.0001	1.087	1.010-1.171	0.027
<b>STEMI (v NonSTEMI)</b>	1.070	0.986-1.161	0.106	1.071	0.982-1.169	0.119
<b>Unspecified(v NonSTEMI)</b>	1.679	1.541-1.830	<.0001	1.744	1.604-1.898	<.0001
<b>Year 2008 (v 2007)</b>	1.036	0.979-1.097	0.219	1.040	0.982-1.102	0.177
<b>Year 2009 (v 2007)</b>	1.020	0.930-1.120	0.671	1.016	0.927-1.114	0.729
<b>Hospital AMI cases (per 50 cases)</b>	0.996	0.993-0.999	0.155	0.993	0.989-0.996	0.004
<b>Teaching hospital</b>	1.019	0.895-1.159	0.778	0.962	0.851-1.087	0.534

A comparison of Hazard Ratios for log-costs in the two difference models were calculated as follows. For the standard Cox model, a hazard ratio of 0.513 corresponded to a 48.7% decrease in the risk of dying. For the extended Cox model, a hazard ratio of 0.700 corresponded to a 30.0% decrease in the risk of dying. A standard percentage change algorithm was then applied (standard Cox HR – extended cox HR/extended cox HR).  $((48.7-30.0)/30.0 = 62.3\%)$ . This represented a 62% overestimation of the protective effect of cost on survival when survivor-treatment bias was not accounted for.

Figure 1 - Patient Example Using Baseline Analysis: Survival Differences Between a Low and High Cost Patient. Contrasting Standard and Extended Cox Model Results



Chapter 4 - References

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## Chapter 5 - Conclusions and Recommendations

Health systems and their associated healthcare organizations are among the most complex and interdependent entities within developed society (Charns & Tweksbury, 1993). These systems have traditionally been developed in decentralized organizational structures that have given rise to fragmented care and have produced less-than-optimal health system performance (Anderson & Karlberg, 2000). Despite substantial policy concerns related to system integration there is a surprisingly limited amount of healthcare research that has taken a continuum of care perspective for many high prevalence diseases. To address this issue, this thesis dissertation took a broad person-centric system level approach to examine the continuum of care for AMI patients in Canada. Despite the well acknowledged role of integrated care models in optimizing quality care and system efficiency (Kodner, 2009; Hoffmarcher et al., 2007; MacAdam, 2008; Starfield, 2009), continuum of care research for AMI is not yet well developed.

The thesis was informed by the IHI's Triple Aim Framework (2008) which has been increasingly taken up by policy and decision makers in Canadian healthcare (Dentzer, 2013; Huynh & Cohen, 2013). This framework puts forward a vision of health system optimization in which health system costs and healthcare quality must be balanced against the needs of the population and improved health outcomes for all (IHI, 2008). From the framework, its four balanced goals related to care, cost, outcomes and equity were used to establish the overall objectives for this thesis. The four thesis objectives are given as follows:

Care – To explore the role of primary and secondary prevention for AMI in primary care prior to a patient's first AMI event, in order to examine the utilization of specific services as per practice guidelines.

Cost – To examine direct healthcare costs and cost drivers for AMI patients along the continuum of care, from prevention in primary care, to treatment in acute care, to disease management following the AMI event.

Equity – To examine differences in the use of services for AMI patients of higher and lower socioeconomic status, to determine if inequities exist and persist across the care trajectory.

Outcomes – To examine the relationship between AMI hospital spending and patient survival outcomes within the Canadian context

In the remainder of this chapter, each objective will be discussed in sequence. First, findings from the research will be discussed, followed by relevant policy implications for the continuum of care and recommendations for future research. Finally a summative conclusion will be provided.

## Care

Without question, AMI patients are a target group that can benefit from integrated care as they move through a care trajectory that optimizes diagnosis, prevention, treatment and disease management (MacAdam, 2008; Young et al., 2003). Integrated care policy strategies often call for more research that examines the full care continuum for such target groups in order to maximize the information available to decision makers in pursuit of the Triple Aim (Kodner & Spreeuwenberg, 2002; Berwick, 2008). Traditionally however, AMI health services research has focused on treatment and management procedures for AMI patients following the AMI event itself. As such, a considerable body of knowledge already exists for AMI patients in acute care settings and in primary care follow up, however care received prior to the AMI event is largely unexplored. Given the preventable nature of AMI and the fact that many AMI risk factors are amenable to primary care intervention, this gap in the pre-state phase of the AMI continuum of care trajectory is problematic. In order for health policy makers to have a holistic understanding of the complete care continuum, research in the diagnosis and prevention of AMI in primary care prior to the AMI event is required.

In study #1, entitled “Inequity in primary and secondary preventive care for AMI? Utilization by socioeconomic status across middle-age and older patients”, we examined the use of specific preventive diagnostic services in an AMI cohort. By selecting only AMI patients, we were able to examine the primary care sector in providing key AMI diagnostic and preventive services for this high risk patient group, who arguably could have benefitted most from them. Given the high risk nature of the cohort examined, we anticipated a high rate of use of all services examined – with the highest rates of use for lipid and glucose testing which are recommended as

a primary prevention screening procedure for all patients above the age of 40 regardless of heart-health risk status (CDA, 2008; Grover et al., 2000; Stone et al., 2013).

While not the primary focus of Study #1, the descriptive data generated in this study related to the proportion of AMI patients receiving specific services contributed useful baseline knowledge about AMI care undertaken in 'pre-state' primary care. According to results, in the two years preceding their AMI, 72% of patients received glucose testing, 64% received lipid-testing, 69% received ECG, 28% received echocardiogram, and 16% received stress-testing.

For primary preventive care services, we observed lipid and glucose screening rates among the AMI patients in the years preceding the event that were consistent with rates of screening in the population in general. Studies in the US and Canada have found that cholesterol and glucose screening rates range between 70 and 80% in the general population (Rifas-Shiman et al., 2008; Borkhoff et al., 2013). The results in the present study which were 64 and 72% for lipid and glucose testing respectively were similar to these general population statistics. Given that lipid and glucose management are generally understood to be cost-effective preventive strategies for AMI for high risk patients (Grundy et al., 1998; Yusuf et al., 2001; DeBacker et al., 2003), these baseline data may point to an opportunity to increase coverage of these primary preventive services in this high risk AMI cohort.

For secondary prevention services, it is difficult to speculate about ideal rates of service use in this high risk patient cohort. Indications for use of secondary preventive services such as ECG, echocardiogram and stress testing typically include symptoms such as angina, shortness of breath and fatigue (Scott Morey, 2000). These symptom-based data were not available at a level of sufficient quality within the administrative data studied, making it difficult to contrast actual versus expected rates of these secondary preventive services. It is particularly interesting however that among the secondary preventive diagnostic tests, ECGs were administered in 69% of the AMI patients in the years preceding AMI. This high rate of use was more consistent with rates of use of primary preventive screening (e.g. lipid and glucose testing), than for the other secondary preventive services studied. While it was not possible to determine from the data whether ECG was being predominantly used as a basic screening tool or in response to specific heart related symptomatology, it does raise questions about how ECG testing is being used in this high risk patient cohort. Although there has been some debate within the literature, ECG is

generally recognized for its effectiveness in secondary prevention (Scott Morey, 2000). There has been some concern raised about the effectiveness and cost-effectiveness of ECG as a primary preventive screening tool (Chaitman, 2007; Chou et al., 2011; Moyer., 2012). The high rates of ECG use prior to AMI observed in this study would appear to suggest that ECG is being used in both primary and secondary prevention. Further research that examines the role of ECG in pre AMI preventive care is required to determine whether or not this particular test is being used as effectively as possible.

The preliminary descriptive data found within this study about the use of specific diagnostic and preventive AMI services within a high risk cohort, contribute new information about the ‘Pre-phase’ phase of care for AMI patients. By generating baseline information about the use of specific services prior to the AMI event, further research that explores patient trajectories across the full continuum of care can be further developed. These descriptive data assist in filling a long standing knowledge gap about the role of primary care for myocardial infarction prior to the AMI event. However given its purely descriptive nature, these baseline data raise many more questions about the relationship between services in the pre-state phase of care and subsequent phases along the care continuum. Further research questions that stem from this initial investigation of preventive care services in primary care include:

- What are appropriate system targets for primary and secondary preventive AMI services for high risk patients prior to the AMI? How do current rates of service use in primary care align with performance targets?
- How does the use of primary and secondary preventive services relate to services that an AMI patient will receive further along the care trajectory? Do patients with higher use of pre-state diagnostic and preventive services also have higher use of treatment and disease management care following the AMI?
- Does the use of services in ‘pre-state’ primary care have any impact on patient survival outcomes following AMI? Or are patient outcomes strictly related to healthcare services received once the AMI has occurred?

## Cost

The entry point for cost objective in this dissertation was the recognition that AMI costing studies along the continuum of care are limited in Canada. Of the research that has been conducted, studies have often relied upon costing data from CIHI and or parallel provincial level sources traditionally focused on data in acute care (Azoulay et al., 2003; CIHI, 2008; CIHI, 2014ab, Heart and Stroke, 2014; Rawson et al., 2012). This has often restricted researchers to developing costing studies focused only on the hospital sector, and has prevented a broader person-centric continuum of care perspective from being fully explored (Segel, 2006; Wodchis, 2013). Without person-centric costing data to support the costing goal of the Triple Aim Framework, system planners will continue to be challenged to accurately assess and monitor patient based AMI costs.

In study #2, entitled “Direct Healthcare Costs of Myocardial Infarction in Canada’s Elderly across the Continuum of Care”, we examined direct costs in primary and acute care across the patient trajectory for seniors. This work was novel in that it considered accumulated costs across the continuum from prevention, to treatment, to disease management, and included physician, hospital and pharmaceutical costs. Study results presented crude average patient costs across a six year continuum of care at \$28,169 (SD 20,794), in Ontario Canada and demonstrated that AMI spending beyond acute care represented one-quarter of total cost for a typical AMI patient (26% for services in the community versus 74% for services within acute care). This cost estimate represents a unique approach to costing in which a dollar value can be applied to a person, rather than a service within a particular sector, to inform future health policy discussions on achieving the Triple Aim for AMI.

This person-centric cost estimate for AMI has a broad range of applications which can be useful to inform policy debate. First, it is important to note that this estimate for AMI at \$28,169 is almost three times the well accepted CIHI costing estimate for AMI at \$11,043 per hospital stay, because hospital readmissions and services received within primary care were also included in the estimate. By altering the unit of analysis for cost from a sector-specific cost to a patient-specific cost, the true cost of AMI is more accurately reflected and the size of the burden of AMI on healthcare is much more apparent.

This cost estimate also provides an intuitive and practical statistic that can be applied to a set of key policy questions using a bottom-up approach (Chapko et al., 2009; Segel, 2006). For example, in response to policy questions related to healthcare cost of illness for seniors in Canada, a prevalence based cost could be generated by multiplying this estimate against the total number of seniors with AMI annually (Segel, 2006; CDC, 2013; Rice & Miller, 1998). For the purposes of demonstration, this would result in a total annual cost of AMI at just more than 783 million for seniors in Canada (based on 27,804 seniors discharged from hospital with AMI in 2009/10 (CIHI, 2011)). Although this example is purely illustrative, by generating a person centric cost estimate for AMI, we demonstrate the importance of moving away from sector-centric costing data, which underestimates the total financial burden of disease.

The present study was limited in that it only calculated person-centric cost estimates for seniors, and not for the full population in Canada. While seniors are most affected by the direct manifestations of AMI (Tu et al., 2009), there remains a need to develop a person-centric cost estimate for all ages. Ideally future work would develop age stratified cost estimates so that more accurate cost projections across the total population could be made available. Furthermore, the costs presented here necessarily underestimate complete healthcare costs in Canada for elderly AMI patients, as costs for home and long term care were not included in the analysis. A number of studies have demonstrated the critical role of other sectors such as home care and rehabilitation care contributing to improved health outcomes for AMI (Alter et al., 2009; Hall et al., 2014). As such, further work is needed enhance the present cost estimate to create the most robust and comprehensive estimates possible with available data sources.

Existing AMI costing research, which has focused predominantly on acute care costs, has served to emphasize the acute nature of the disease and the treatments used to respond to the AMI event in the hospital setting. However this narrow type of costing study has generally failed to reflect the multiple sectors involved in addressing myocardial infarction through diagnosis, prevention, treatment and disease management across the continuum of care. The research in the present thesis dissertation provided useful baseline information about costs and cost drivers for AMI patients across the continuum of care to help inform AMI continuum of care approaches in Canada. These estimates fill an important gap in the literature pertaining to comprehensive person-centric AMI costs, but also in delineating costs along the care continuum which can be

used in future research to examine the relationship between spending across the different phases of the patient care trajectory. Future work that links costs to other Triple Aim goals including quality and outcomes will be critical to help provide more meaningful context for the impact of the present costing study in order to assist policy makers in planning and decision making. A number of questions arise from the work for which future research will be required.

- What is the total AMI patient cost for different age strata within the population? What percentage of total costs are contributed by the tertiary care sector which were not included in the original estimate?
- Do patients who receive more costly care in the primary care sector prior to their AMI continue to be high cost users across their care trajectory? Or does higher spending prior to AMI reduce the total spending profile?
- Which cost-drivers predict high and low cost across the care continuum? How can earlier interventions for co-morbid conditions adjust the impact of these cost drivers on overall cost?

## Equity

In addition to ‘care’ and ‘costs’, research has also generally failed to examine equity in access to care across the AMI care continuum. The notion of ‘seamless access to care for all’ represents a core component for integrated care strategies in general, and is at the heart of organizational design for the Triple Aim Framework in order to achieve maximally efficient and effective health care systems (Berwick, 2008; Scott, 1992). The role of primary care in creating a platform for equitable integrated care in many health systems around the world is well established (WHO, 2008; PAHO, 2007). According to Starfield (2009), primary care fulfils four cardinal functions for equitable integrated healthcare including; being the first contact with the system; ensuring longitudinal care over time; addressing all health-related needs by delivering comprehensive care, and supporting care coordination for patients who receive care in other sectors of the system. Given the established role of primary care in achieving equitable integrated care across the care continuum, it was expected that any inequities occurring in the early phase of care could have implications for AMI patients across the care trajectory.

In the first study entitled, “Inequity in primary and secondary preventive care for AMI? Utilization by socioeconomic status across middle-age and older patients”, we examined socioeconomic differences in the use of specific preventive diagnostic services in a high risk AMI cohort. Given the universal nature of Canada’s healthcare system, we hypothesized that low SES patients should not experience a lower use of any preventive care service compared to their high income counterparts. Results from this study demonstrated no socioeconomic differences in many of primary and secondary preventive services examined, verifying the hypothesis that preventive care for AMI patients is equitable in most cases. This finding was consistent with numerous other studies focused on access to physicians, in which primary care has been shown to be equitable in Canada (Allin, 2008; Asada & Kepar, 2007; Frohlich et al., 2002; McIssac et al, 1997; Veugelers & Yip, 2003).

Small differences in the use of primary preventive services were found among middle-aged patients. For those between 40 and 65, low SES patients were 12% and 10% less likely to receive lipid and glucose-testing respectively compared to their high SES counterparts. Although the size of the socioeconomic gap for either test was not large, these findings do raise some concern about primary preventive care for AMI within younger age groups. These findings may point to the need for targeted equity approaches for primary preventive care that prioritize younger age groups to ensure healthy aging across the age spectrum (Peel et al., 2005).

Study 2, entitled “Direct Healthcare Costs of Myocardial Infarction in Canada’s Elderly across the Continuum of Care” shed some light on equity across AMI care trajectory. Although not the primary focus on study 2, by examining SES across each phase of the care continuum we were able to gauge the role of SES on healthcare spending in each phase of care. According to study results, SES was not a significant predictor of overall healthcare costs in either community based pre or post-state phases of care. Only in the state phase of acute care were socioeconomic differences in spending observed, however in this case low SES patients were found to be slightly more costly than their low SES counterparts (at 3.5% higher likelihood of receiving higher costing care). This finding likely reflected the equitable ‘higher use for higher needs’ approach given that low SES patients are recognized to have poorer overall health status (Capewell & Graham, 2010; Harkins et al., 2010; Marmot, 2010). This finding was consistent with the general findings of study 1 in which primary care services early in the care trajectory

were found to be equitable overall. It is possible that equity in primary care established in the early phase of care (prior to the AMI) laid the foundation for equity across the care continuum, according to Starfield's vision for primary care and its four cardinal functions (Starfield, 2009). Further research will be required to determine the way in which the gateway and coordination functions in primary care create the conditions for equity across the AMI care trajectory.

The results of the present research provided some optimistic findings for equity across the care continuum for AMI, however results were fairly preliminary. More research is required that uses alternative measures of socioeconomic status and that explores challenges at critical junction points between organizational silos to more fully explore the issue of equity across the AMI care trajectory. Future work will also need to consider other aspects of potential inequity in access to care including differences based on sex, patient's urban or rural status, ethnicity, language, etc. Although not the focus of this thesis, a number of potentially interesting differences in the use of primary and secondary preventive care were found for across sex and patient's urban/rural status. These findings should be further examined and brought to light as important areas for potential inequities in primary care that can have significant impact on health system performance and overall system efficiency. The present set of studies contributed important baseline information to fill a knowledge gap in the Triple Aim framework for AMI, however it also raised a number of important questions:

- Do different methods of measuring socioeconomic status such as the social and material components of the deprivation index demonstrate similar patterns of equitable care and cost across the patient trajectory?
- Are there inequities in access to care when patient's sex or urban/rural status are examined rather than socioeconomic status?
- How can the inequities in primary preventive care procedures be addressed for the middle aged population? What healthcare policies, strategies and initiatives that have been shown to be useful in addressing inequities in preventive screening for other diseases might be adaptable to address heart disease in primary care?
- Which specific gateway and coordination functions within the primary care sector are most fundamental in ensuring equitable and seamless delivery across the care continuum?

## Outcomes

The person-centric integrated care approach is a central tenant of the Triple Aim framework, based on the fundamental position that policy level, organizational and point of care processes that improve seamless care will ultimately save the system money and improve healthcare outcomes (Kodner & Spreeuwenberg, 2002). As population aging and advancements in new technologies drive rising demands on healthcare spending, governments increasingly face pressure to consider integrated health system reform strategies that address value for money and health system sustainability (Blomqvist & Busby, 2012). Core to value for money debate is the question, ‘Does more costly care produce better patient outcomes?’ This question is relevant for a multitude of health conditions that generate significant burden of illness on the population and on the healthcare system itself (Joint & Jha, 2012).

AMI represents a key health condition for which the relationship between costs and outcomes must be better explored within the research. Given that hospital spending in the ‘event’ phase for AMI represents the largest sector of spending across the care continuum, one of the most critical areas of research should focus on the relationship between hospital spending and AMI patient outcomes. Despite the need for such research however, the literature in Canada is limited (Stukel et al., 2012). This is likely due to a set of methodological challenges that create difficulty in adequately addressing the cost-outcomes question at the patient level. Limited research outside of Canada has generally found a positive relationship between spending and survival for AMI, however it is unclear whether or not this relationship can be found in the Canadian context, in which the single-payer universal healthcare system operates outside of the influence of market driven forces (McClellan et al., 1994; Schreyogg & Stargardt, 2010; Stargardt et al., 2013).

In study 3, entitled “Does Higher Hospital Spending Improve Survival Outcomes for Myocardial Infarction? Examining the Cost-Outcomes Relationship using Time-Varying Covariates”, we applied an innovative statistical technique to respond to this knowledge gap. Although the study was presented primarily as a methodology paper, it addressed the cost-outcomes policy issue by quantifying the return on investment of AMI hospital spending on survival outcomes at the patient level. In our analysis, we demonstrated that an increase in one log unit spending in the hospital event phase reduced the likelihood of dying by 30% within a one year follow up period.

In the practical patient example presented, this increase in log spending translated into a difference in spending for a low cost user (\$8,699) versus high cost user spending (\$24,000) at the 25 and 75<sup>th</sup> percentiles. Results from this study aligned with findings from similar studies conducted outside of Canada, and suggested that the ‘more is better’ relationship is upheld even in the universal Canadian context. By making this kind of policy relevant research and methodology available, it is anticipated that decision makers will be better equipped to understand and track changes to the cost-outcomes relationship over time as policy and programs are modified to improve integrated care for AMI.

This innovative study exploring the relationship between hospital spending and AMI patient outcomes filled an important knowledge gap by providing baseline information that is relevant for decision makers in pursuing the Triple Aim framework. However, it was limited in that it only considered the relationship between healthcare spending and outcomes within one phase of the AMI care trajectory. As more and more decision makers require relevant and robust research that makes clear connections between health system spending and patient outcomes across the care continuum, future research must consider the linkages between spending in each phase of care and its relationship with health outcomes to achieve the balanced goals of the Triple Aim.

The methodology applied in this work may also be relevant for assessing the relationship between costs and outcomes for other health conditions. This study raises further questions about the relationship between costs and outcomes across the continuum of care. These questions include:

- How does spending across each phase of the care continuum (pre-event phase, event phase, and post-state phase) contribute to overall patient outcomes for AMI?
- Do patients who are persistently high-cost users across all phases of care have different health outcomes compared to patients who are high cost users in only one phase of care?
- Do cost-outcomes studies at the patient level for other acute and chronic disease conditions demonstrate a consistent relationship between higher spending and improved patient outcomes?

## Final Summary

As a critical partner in reducing the disease burden of AMI in Canada, the healthcare system continues to evolve to meet newly emerging health needs within the population (Cohen et al., 2014). The aging population and the shift from acute to chronic disease are two key factors driving health system leaders to find new and innovative ways to create synergy between sectors serving in the continuum of care. Central to this evolving approach is the notion of person-centred integrated care, such that health organizations and the larger health system infrastructure can achieve the vision of the Triple Aim framework. According to Kodner (2009), “In essence, integrated care can be seen as a demand-driven response to what generally ails modern-day healthcare: access concerns, fragmented services, disjointed care, less than optimal quality, system inefficiencies and difficult to control costs.” The research presented in this thesis dissertation put forward some of the baseline information required to advance the continuum of care approach for AMI in Canada. Future continuum of care research that can enhance our knowledge about how the system is performing and ‘integrating’ will undoubtedly be critical in guiding and monitoring future policy and decision making to reduce the disease burden of AMI, and may serve to bring Canada closer to its visionary goal - in which health system costs and healthcare quality can be balanced against the needs of the population and improved health outcomes for all.

## Chapter 5 - References

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