Revascularization and heart attack outcomes

Helen Johansen, Cyril Nair, Luling Mao and Michael Wolfson

Abstract

Objectives
This article focuses on rates of revascularization and mortality among people admitted to hospital after an acute myocardial infarction (AMI).

Data source
The hospital data are from the Person-oriented Information Database. Information on deaths is from the Canadian Mortality Database.

Analytical techniques
Hospital records for Nova Scotia, Saskatchewan, Alberta and British Columbia were linked to identify AMI patients admitted between April 1, 1995 and March 31, 1996. Patients with no admission for AMI in the previous 12 months were followed for one year to determine what percentage underwent percutaneous transluminal coronary angioplasty and/or coronary artery bypass graft surgery. The risk of being revascularized and the risk of dying were estimated.

Main results
In the year after hospitalization, 25% of AMI patients were revascularized. Rates of revascularization were relatively low for women, very elderly people, and individuals with other health problems. Revascularization was significantly associated with a lower risk of dying for male, but not female, AMI patients.

Key words
acute myocardial infarction, percutaneous transluminal coronary angioplasty, coronary artery bypass graft, medical record linkage, mortality

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Heart attack (acute myocardial infarction or AMI) is a leading cause of hospitalization and death in Canada.[1,2] A heart attack usually occurs when a blockage (most often a blood clot) in a coronary artery severely restricts or cuts off the blood supply to a region of the heart. If this happens for more than a few minutes, heart tissue dies. The heart's ability to keep pumping is directly related to the extent and site of the damaged tissue (infarction).[3] In 1995/96, close to 59,000 hospital admissions were attributable to AMI, accounting for 11% of male deaths and 10% of female deaths.

Percutaneous transluminal coronary angioplasty (PCTA) and coronary artery bypass graft surgery (CABG) are revascularization methods that are commonly used to improve blood flow to the heart among people with coronary heart disease. Because the risks associated with surgery are higher for people whose heart muscle was damaged by a heart attack, not all AMI patients are good candidates for these procedures. However, revascularization may be performed on AMI patients for whom other therapies are not suitable.[3]

<p style="text-align:center">**Methods**</p>

Data sources

Hospital morbidity data are from the Canadian Institute for Health Information, which provides morbidity files annually to Statistics Canada. Each record contains information from an inpatient's hospital chart and pertains to one hospital separation. The data in this analysis are from the Person-oriented Information Database, which Statistics Canada builds from these hospital morbidity files. Mortality data are from the Canadian Mortality Database.

The Postal Code Conversion file was used to determine Census Enumeration Areas from the patient's residential postal code. Health region (as of 1999) was based on the Census Enumeration Area.

Analytical techniques

To identify heart attack patients, hospital records for Nova Scotia, Saskatchewan, Alberta and British Columbia were linked using patient identification numbers. Patients discharged with an acute myocardial infarction (AMI) between April 1, 1995 and March 31, 1996 in Nova Scotia, Saskatchewan, Alberta and British Columbia were followed for the succeeding year to determine revascularization and mortality (all causes). These provinces were chosen because patients could be traced for out-of-hospital deaths.

An AMI patient was defined as someone who had one or more hospital stays for AMI during the year. The diagnostic code 410 in the *International Classification of Diseases, Ninth Revision* (ICD-9)[4] was used to identify AMI patients. They were followed for one year to determine if they had percutaneous transluminal coronary angioplasty (PTCA) and/or coronary artery bypass graft surgery (CABG) surgery. The *Canadian Classification of Procedures* (CCP)[5] was used to identify PTCA (48.00-48.08, 51.59) and CABG (48.11-48.19).

The first primary diagnosis of AMI during the 1995/96 fiscal year was considered the "index event." An index event makes it possible to calculate time from AMI to revascularization without depending on referral time for angiography.

Calculations are based on patients who had an AMI in the 1995/96 fiscal year and who had *not* been hospitalized for AMI in the preceding year. They are referred to as having a one-year "wash-out" period. Patients who had had an AMI during the previous year and were waiting for revascularization when they had the attack that caused their admission to hospital in 1995/96 were excluded because the second AMI may have given them a higher priority on a waiting list, and thus, a relatively short time would elapse before PTCA or CABG. A total of 12,648 patients were hospitalized for AMI in the four provinces in 1995/96; the wash-out eliminated 308.

Some patients are admitted to hospital for tests to rule out a heart attack. To reduce false-positive diagnoses, patients who were admitted for suspected AMI, but who were discharged alive within two days and who had neither a PTCA nor a CABG in the subsequent year were also excluded. These exclusions represented another 69 patients, leaving 12,271 patients in the study.

Time-to-procedure was estimated by subtracting the admission date of the index event from the admission date of the first hospital stay during which revascularization occurred and adding half the length of stay of the revascularization visit. This definition encompasses variations in waiting time to see a specialist and placement on a waiting list for hospitalization. If the procedure occurred during the index visit, time-to-procedure was considered half the length of stay. This was necessary because not all jurisdictions report the date when each procedure was performed.

For all four provinces, in-hospital deaths were determined from hospital records. For out-of-hospital deaths, provincial health insurance numbers were used to link death certificates to hospital records for Saskatchewan, Alberta, and British Columbia. Because health insurance numbers are not available on all death certificates, birth date, sex and postal code were used to refine the linkage. In Nova Scotia, health insurance registration data were used to determine mortality of AMI patients.

Cox proportional hazards regression was used to adjust revascularization for co-morbidity and age. Separate analyses were done for men and women. The Charlson Index was used to adjust for co-morbidity (see *Charlson Index*). Individual health regions in the models had populations of at least 100,000; less populous regions were included in the models as "other" Saskatchewan, "other" Alberta, and "other" British Columbia. The revascularization variables in the mortality models are time-dependent covariates; that is, the effect of revascularization on death is not considered until after the revascularization is performed.

Two models (one for 30-day and one for one-year mortality) created by the Institute for Clinical Evaluative Sciences (ICES)—the Tu method—to adjust mortality rates for differences in age, sex and co-morbidity were also used. The observed number of deaths was summed in each health region and divided by the predicted number of deaths found by summing the probabilities of death given by the model. The resulting mortality ratio was then multiplied by the overall cohort mortality rate to yield the risk-adjusted mortality rate for the region. An estimate of the variance obtained from the logistic model was used to calculate 95% confidence intervals. These results can be interpreted as the mortality rate a region would have if it were similar to the average case mix in Ontario for the same inception cohort used in the model development (1994/95-1996/97).

The Cox proportional hazard regression with the Charlson Index and the Tu model gave similar results for one-year heart attack mortality. Because the regression model allowed revascularization to be included, only the Cox regression results are reported in this article.

With data from four provinces—Nova Scotia, Saskatchewan, Alberta and British Columbia—this analysis examines revascularization and mortality among heart attack patients during the year after their admission to hospital for AMI (see *Methods* and *Limitations*). These provinces were chosen because patients could be traced for out-of-hospital deaths. Rates of revascularization and mortality are presented by sex, age and health region. The aim is to determine the factors associated with revascularization, and then, controlling for the other factors, to determine if revascularization is associated with survival.

Health region data are used to partially account for variables that are not available in hospital and mortality statistics, but that could differ geographically: physician factors, health care facilities, and patient characteristics, for example.

Hospital admissions

In 1995/96, 12,271 people aged 20 or older in Nova Scotia, Saskatchewan, Alberta and British Columbia were admitted to hospital with a primary diagnosis of AMI and no previous AMI hospitalization in the past year: 8,255 men and 4,016 women.

These AMI patients were relatively old: 62% were 65 or older. In each age group up to and including 80-to-84, male patients exceeded female patients (Chart 1). Among the very old, women outnumbered men, in part a reflection of women's generally greater longevity.

In the year after their heart attack, 17% of the patients underwent PTCA, and 9% had CABG surgery (see *Cardiac procedures*). Overall, 25% were revascularized, slightly less than the sum of those who had a PTCA and those who had CABG surgery, because some patients (1%) had both procedures (Table 1).[6,7]

Most revascularization of AMI patients occurred within a month of their heart attack (Chart 2). In fact, a substantial proportion was performed in the first two weeks. All AMI patients, however, were not equally likely (or unlikely) to be revascularized.

Chart 1
Number of heart attack patients hospitalized between April 1, 1995 and March 31, 1996, by age group and sex, four provinces†
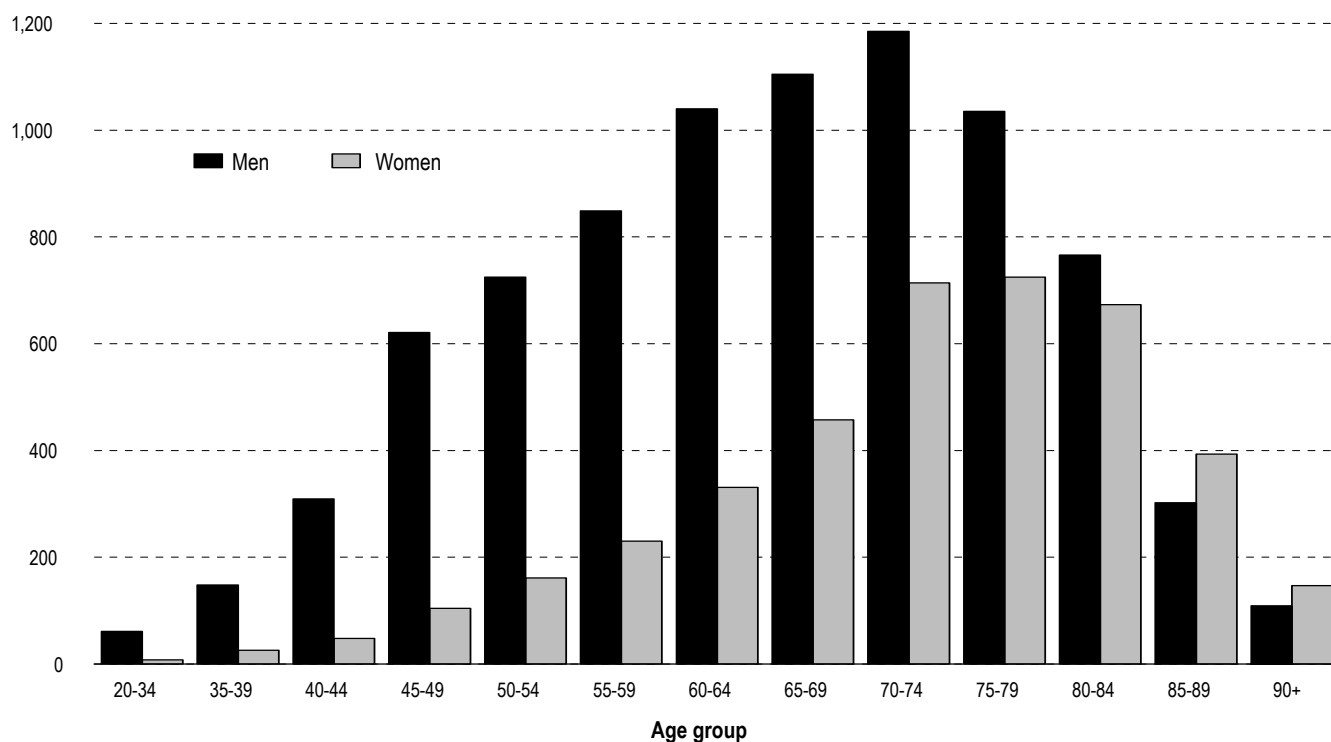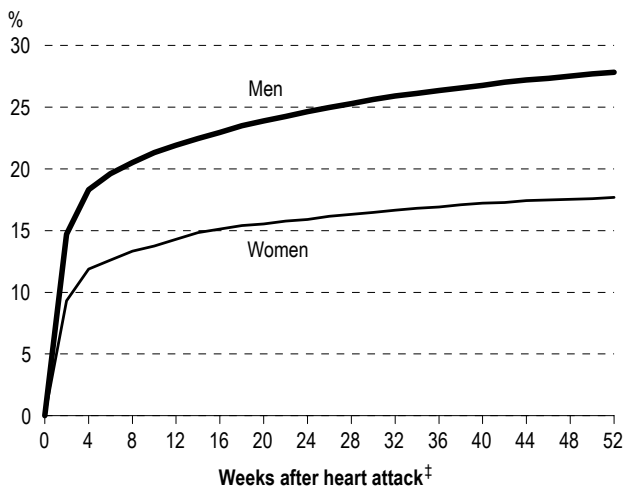

Data source: *Person-oriented Information Database*
† Nova Scotia, Saskatchewan, Alberta, British Columbia

Table 1
Percentage of heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who were revascularized within one year, by sex, four provinces[†]

	Total	Men	Women
	%	%	%
Total[‡]	**25.2**	**28.6**	**18.1**
Percutaneous transluminal coronary angioplasty (PTCA) only	16.1	18.0	12.1
Coronary artery bypass graft surgery (CABG) only	8.3	9.7	5.6
Both PTCA and CABG	0.8	0.9	0.5

Data source: *Person-oriented Information Database*
Note: *Because of rounding, detail may not add to totals.*
† Nova Scotia, Saskatchewan, Alberta, British Columbia
‡ May be less than sum of PTCA and CABG, as some patients had both.

Chart 2
Cumulative rate of revascularization among heart attack patients hospitalized between April 1, 1995 and March 31, 1996, by sex, four provinces[†]

Data source: *Person-oriented Information Data Base*
† Nova Scotia, Saskatchewan, Alberta, British Columbia
‡ First primary diagnosis of acute myocardial infarction

Revascularization rates differ

In 1995/96, a higher percentage of male than female heart attack patients in the four provinces underwent PCTA and CABG. Other research, too, has shown female AMI patients to be less likely than male patients to have invasive cardiac procedures.[8,9] An

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Percutaneous transluminal coronary angioplasty (PCTA) and coronary artery bypass graft (CABG) are revascularization methods that improve the flow of blood to the heart.[3] They are used most often to treat coronary artery disease, a condition in which fatty deposits accumulate in the cells lining the artery wall and obstruct blood flow.

For PTCA, a large peripheral artery (usually the femoral artery in the leg) is punctured with a needle and a guide wire is threaded through the needle into the arterial system, through the aorta and into the obstructed coronary artery. A catheter with a balloon attached to the tip is threaded over the guide wire and into the diseased coronary artery to the obstructed area. The balloon is inflated for several seconds. It may be inflated and deflated a number of times, thereby reducing the obstruction. To keep the artery open after angioplasty, a device made of wire mesh (a stent) may be inserted into the artery.
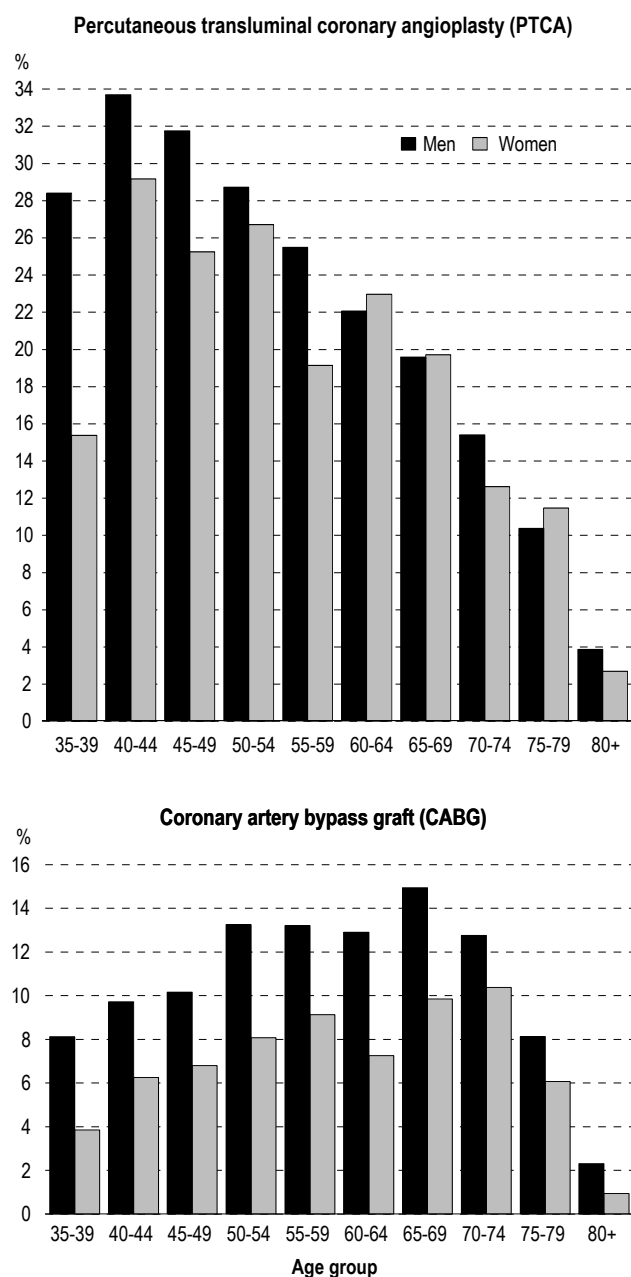
CABG involves grafting veins (usually from the leg) or arteries (usually from beneath the breastbone) from the aorta to the coronary artery, thus bypassing the obstructed area. Bypass surgery is highly effective in people who have angina and coronary heart disease that is not widespread. It can improve exercise tolerance, reduce symptoms, and decrease the number or dose of drugs needed. Patients most likely to have bypass surgery are those with severe angina that has not improved with drug therapy and no other conditions that would make surgery hazardous.

Ontario study found rates of both PTCA and CABG to be lower among women.[10] And in the United States, sex differences remained even after matching hospital of admission and controlling for other factors that can influence procedure rates.[11] To some degree, women's lower rate may be influenced by their longer life expectancy, which results in a higher proportion of women with AMIs in the oldest age groups—the least likely to undergo revascularization.[12-14]

For both sexes, PCTA rates were highest among heart attack patients in their forties and early fifties, then generally declined at older ages (Chart 3). In most age groups, rates were higher among men than women.

CABG surgery was less common than PCTA among heart attack patients. CABG rates were

Chart 3
Percentage of heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who were revascularized within one year, by age and sex, four provinces†

Percutaneous transluminal coronary angioplasty (PTCA)

Coronary artery bypass graft (CABG)

Age group

Data source: *Person-oriented Information Data Base*
† Nova Scotia, Saskatchewan, Alberta, British Columbia

Table 2
Percentage of heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who were revascularized within one year, by health region, four provinces

Health region	%
Nova Scotia	
Western	17.1
Central	19.3
Northern	20.1
Eastern	14.8
Saskatchewan	
Regina	26.8
Saskatoon	26.2
Others†	19.9
Alberta	
Chinook Regional Health Authority	29.9
Calgary Regional Health Authority	43.1
David Thompson Regional Health Authority	25.2
East Central Regional Health Authority	18.5
Capital Health Authority	33.0
Lakeland Regional Health Authority	24.7
Others†	26.0
British Columbia	
North Okanagan	23.4
South Okanagan/Similkameen	23.3
Thompson	14.1
Fraser Valley	21.3
South Fraser Valley	25.3
Simon Fraser	29.6
Central Vancouver Island	29.8
Upper Island/Central Coast	31.3
Northern Interior	25.5
Vancouver	22.5
Burnaby	23.5
North Shore	15.8
Richmond	26.1
Capital	32.8
Others†	15.6

Data source: *Person-oriented Information Database*
† Less than 100,000 population

The percentage of heart attack patients who were revascularized within one year varied among large health regions (population over 100,000). For example, in Alberta, the range was from 19% to 43%, and in British Columbia, from 14% to 33% (Table 2). Wide differences among health regions have also been documented in Manitoba and Ontario.[15,16]

Factors related to revascularization

Although female heart attack patients were more likely than male patients to be very elderly and to have more illnesses (see *Charlson Index*), even when these factors were taken into account, women were still less likely to be revascularized, particularly with CABG surgery (data not shown).

highest for people in their late sixties and early seventies, and in every age group, men had a higher rate than did women. Rates among men fell from age 70 on, and among women, from age 75 on.

When co-morbidity and health region were taken into account, the likelihood of being revascularized declined at older ages for AMI patients of both sexes (Table 3). Among men, each additional year meant a 2% reduction in the chance of revascularization; among women, the comparable figure was 3%.

Table 3
Hazard ratios for revascularization within one year, male and female heart attack patients hospitalized between April 1, 1995 and March 31, 1996, four provinces

	Men		Women	
	Hazard ratio	95% confidence interval	Hazard ratio	95% confidence interval
Age	0.98*	0.97, 0.98	0.97*	0.96, 0.97
Charlson Index	0.90*	0.86, 0.94	0.92*	0.86, 0.98
Nova Scotia				
Western	0.34*	0.26, 0.45	0.38*	0.24, 0.60
Central	0.37*	0.28, 0.49	0.42*	0.27, 0.65
Northern	0.35*	0.25, 0.49	0.58*	0.35, 0.95
Eastern	0.30*	0.22, 0.41	0.27*	0.15, 0.46
Saskatchewan				
Regina	0.66*	0.52, 0.84	0.48*	0.30, 0.78
Saskatoon	0.66*	0.50, 0.85	0.59*	0.35, 0.97
Others†	0.45*	0.37, 0.55	0.49*	0.34, 0.71
Alberta				
Chinook Regional Health Authority	0.74*	0.55, 0.98	0.74	0.43, 1.28
David Thompson Regional Health Authority	0.49*	0.36, 0.68	0.63	0.35, 1.11
East Central Regional Health Authority	0.49*	0.32, 0.75	0.27*	0.10, 0.73
Capital Health Authority	0.71*	0.60, 0.85	0.86	0.62, 1.18
Lakeland Regional Health Authority	0.50*	0.34, 0.73	0.60	0.31, 1.16
Others†	0.59*	0.49, 0.70	0.68*	0.49, 0.95
British Columbia				
North Okanagan	0.55*	0.38, 0.78	0.68	0.39, 1.18
South Okanagan/ Similkameen	0.60*	0.45, 0.78	0.55*	0.33, 0.91
Thompson	0.34*	0.22, 0.52	0.14*	0.03, 0.55
Fraser Valley	0.49*	0.38, 0.64	0.51*	0.32, 0.83
South Fraser Valley	0.58*	0.47, 0.71	0.65*	0.45, 0.93
Simon Fraser	0.72*	0.55, 0.93	0.71	0.45, 1.11
Central Vancouver Island	0.75*	0.59, 0.95	0.77	0.50, 1.19
Upper Island/Central Coast	0.86	0.62, 1.21	0.68	0.36, 1.28
Northern Interior	0.41*	0.28, 0.61	0.45*	0.22, 0.93
Vancouver	0.61*	0.48, 0.77	0.55*	0.35, 0.87
Burnaby	0.53*	0.37, 0.75	0.78	0.46, 1.31
North Shore	0.40*	0.28, 0.58	0.34*	0.15, 0.77
Richmond	0.62*	0.43, 0.89	0.54	0.25, 1.18
Capital	0.97	0.77, 1.21	1.13	0.78, 1.64
Others†	0.41*	0.34, 0.51	0.33*	0.21, 0.51

Data source: *Person-oriented Information Database*
Note: *Reference group is Calgary Regional Health Authority.*
† Less than 100,000 population
* p < 0.05

The more illnesses heart attack patients had, the less likely they were to undergo revascularization. With each point-increase in their Charlson Index score, men were 10% less likely to be revascularized; for women, the reduction was 8%.

Many other variables that could affect revascularization rates, such as hospital and physician factors and socio-economic characteristics of patients, are not available from hospital records. To partially account for these potential influences, health region was considered in the model. The Calgary Regional Health Authority (RHA), where revascularization rates were highest for both sexes, was used as the reference group.

Compared with male heart attack patients in the Calgary RHA, the hazard ratios for revascularization were significantly low for male patients in every other large health region in the four provinces, except for two in British Columbia.

Female heart attack patients in each Nova Scotia and Saskatchewan health region also had significantly low hazard ratios for revascularization, compared with the Calgary RHA. However, in British Columbia, ratios were significantly low in just half of the 14 regions. And in Alberta, the hazard ratio was significantly low in just one health region.

Charlson Index

Studies that use administrative data bases to examine the outcomes of medical care must account for disease severity and co-morbid conditions. The Charlson Index is a common measure of clinical co-morbidity designed for use with medical records.[17-20] Weights for each co-morbidity reported for a patient are summed to give an index value. More severe conditions have higher weights (Appendix).

The Charlson Index[17] showed less co-morbidity among male than female heart attack patients in the four provinces. Whereas 61% of the men had a Charlson Index in the 0-to-1 range, this was the case for 50% of the women. On the other hand, for 25% of the women, the Index was at least 3, compared with 19% of the men.

Most mortality in early weeks

The majority of people admitted to hospital after a heart attack survive, and deaths that do occur usually happen in the early weeks (Chart 4). Within a month of the event, 15% of AMI patients in the four provinces had died; by the end of a year, the death toll had risen to 22% (Table 4).

As might be expected, elderly AMI patients had less favourable outcomes than younger patients. The one-month mortality rate was 31% at age 80 or older, compared with about 2% at ages 20 to 44. After a year, 47% of patients aged 80 or older had died, compared with 3% of the 20- to 44-year-olds.

Mortality rates were higher for women than men: a year after having suffered a heart attack, 29% of women had died, compared with 19% of men. Even when age and co-morbidity were considered, the likelihood of dying was significantly higher for female than male heart attack patients (data not shown).

Regional variations

One-year mortality among heart attack patients varied considerably by health region (Table 5). In the large Alberta regions, the percentage who died within a year ranged from 15% to 31%. In British Columbia, the range was from 14% to 29%, although the relatively high percentages in some

Chart 4
Cumulative rate of death among heart attack patients hospitalized between April 1, 1995 and March 31, 1996, by sex, four provinces†
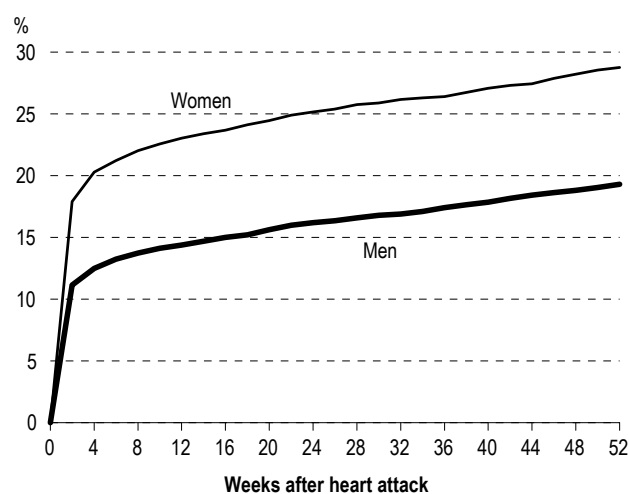
Data source: Person-oriented Information Database
† Nova Scotia, Saskatchewan, Alberta, British Columbia

Table 4
Percentage of heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who died within 30 days and within one year, by age and sex, four provinces†

	Died within 30 days			Died within one year		
	Total	Men	Women	Total	Men	Women
	%			%		
Total	**15.2**	**12.6**	**20.4**	**22.4**	**19.3**	**28.8**
20-44	2.2	1.9	3.7	3.0	2.9	3.7
45-64	5.9	5.6	7.1	8.5	7.8	11.0
65-79	16.6	15.2	19.0	24.2	23.4	25.7
80+	30.9	29.2	32.5	46.7	46.2	47.2

Data source: Person-oriented Information Database, Mortality Database
† Nova Scotia, Saskatchewan, Alberta, British Columbia

Table 5
Percentage of heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who died within one year, by health region, four provinces

Health region	%
Nova Scotia	
Western	21.2
Central	19.8
Northern	18.3
Eastern	22.0
Saskatchewan	
Regina	22.8
Saskatoon	24.1
Others†	23.7
Alberta	
Chinook Regional Health Authority	20.5
Calgary Regional Health Authority	14.7
David Thompson Regional Health Authority	18.7
East Central Regional Health Authority	30.8
Capital Health Authority	18.6
Lakeland Regional Health Authority	21.0
Others†	18.0
British Columbia	
North Okanagan	24.4
South Okanagan/Similkameen	27.1
Thompson	28.8
Fraser Valley	22.8
South Fraser Valley	21.0
Simon Fraser	26.0
Central Vancouver Island	23.6
Upper Island/Central Coast	28.8
Northern Interior	13.9
Vancouver	29.4
Burnaby	27.2
North Shore	26.1
Richmond	22.2
Capital	24.9
Others†	21.2

Data source: Person-oriented Information Database, Mortality Database
† Less than 100,000 population

regions may be related to the province's hospital admission policy (see *Limitations*). In British Columbia, people who die in the emergency ward within six hours of arrival may be deemed inpatients.

There was much less difference in mortality rates among health regions in Nova Scotia, where percentages varied from 18% to 22%, and in Saskatchewan, where the range was from 23% and 24%.

Revascularization and mortality

The mortality rate of heart attack patients who had been revascularized was lower than the rate among those who had not been revascularized. Just over 5% of men who had undergone revascularization died within the year, compared with 25% who had not been revascularized. For female AMI patients, the corresponding figures were 9% and 33%. But patients who were revascularized tended to be both younger and healthier than those who were not. Thus, to assess the independent association of each variable with post-heart attack mortality, it is necessary to account for these interrelationships. This was done by adjusting for age, co-morbidity, health region and revascularization.

Not surprisingly, hazard ratios of dying within the year rose with age and with the number of co-morbidities (Table 6). Each additional year of age increased the risk of dying by 7% among men and by 6% among women. For both sexes, a 1-point increment in their score on the Charlson Index was associated with a 21% increase in their risk of dying.

In health regions where the rate of revascularization was relatively high, the percentage of heart attack patients who died tended to be lower (Chart 5). Still, health regions differ in factors other than rates of revascularization that might affect death rates. These include age, sex and co-morbidity of patients.

When the effects of age and co-morbidity, as well as revascularization, were taken into account, among male heart attack patients, the hazard ratios for dying within a year did not differ significantly from the Calgary RHA in any of the Nova Scotia health regions, and the ratio was significantly high (based on a 95% confidence interval) in only one Alberta health region. However, compared with their

Table 6

Hazard ratios for death within one year, male and female heart attack patients hospitalized between April 1, 1995 and March 31, 1996, four provinces

	Men		Women	
	Hazard ratio	95% confidence interval	Hazard ratio	95% confidence interval
Age	1.07*	1.06, 1.07	1.06*	1.05, 1.07
Charlson Index	1.21*	1.18, 1.25	1.21*	1.16, 1.27
Revascularization				
Within 0-14 days	0.73*	0.57, 0.94	0.87	0.63, 1.22
Within 15-365 days	0.66*	0.47, 0.91	1.05	0.69, 1.61
Nova Scotia				
Western	1.25	0.89, 1.76	0.93	0.64, 1.35
Central	1.07	0.74, 1.54	0.97	0.67, 1.41
Northern	1.10	0.71, 1.71	0.92	0.58, 1.46
Eastern	1.20	0.84, 1.71	1.23	0.85, 1.79
Saskatchewan				
Regina	1.51*	1.06, 2.16	1.12	0.76, 1.65
Saskatoon	1.55*	1.07, 2.23	1.12	0.74, 1.69
Others†	1.43*	1.08, 1.90	1.18	0.86, 1.61
Alberta				
Chinook Regional Health Authority	0.91	0.58, 1.43	1.12	0.71, 1.77
David Thompson Regional Health Authority	1.34	0.87, 2.06	0.83	0.47, 1.47
East Central Regional Health Authority	1.81*	1.16, 2.82	1.66	0.99, 2.79
Capital Health Authority	1.35	0.99, 1.82	0.88	0.63, 1.24
Lakeland Regional Health Authority	1.24	0.76, 2.02	1.01	0.56, 1.83
Others†	1.31	0.98, 1.75	0.95	0.68, 1.34
British Columbia				
North Okanagan	1.16	0.73, 1.85	1.59*	1.02, 2.49
South Okanagan/ Similkameen	1.53*	1.07, 2.19	1.22	0.83, 1.80
Thompson	2.35*	1.56, 3.56	1.42	0.82, 2.44
Fraser Valley	1.40	0.99, 1.99	0.92	0.62, 1.37
South Fraser Valley	1.23	0.89, 1.70	0.97	0.69, 1.37
Simon Fraser	1.87*	1.27, 2.74	1.43	0.98, 2.08
Central Vancouver Island	1.39	0.99, 1.97	1.21	0.80, 1.83
Upper Island/Central Coast	2.30*	1.51, 3.51	1.21	0.69, 2.12
Northern Interior	1.30	0.71, 2.40	1.03	0.47, 2.25
Vancouver	1.59*	1.16, 2.16	1.30	0.93, 1.82
Burnaby	1.47	0.97, 2.22	1.17	0.75, 1.84
North Shore	1.17	0.79, 1.72	1.19	0.73, 1.94
Richmond	1.05	0.62, 1.78	1.21	0.71, 2.05
Capital	1.33	0.95, 1.86	1.08	0.75, 1.54
Others†	1.67*	1.25, 2.23	1.22	0.90, 1.67

Data source: *Person-oriented Information Database*
Note: *Reference group is Calgary Regional Health Authority.*
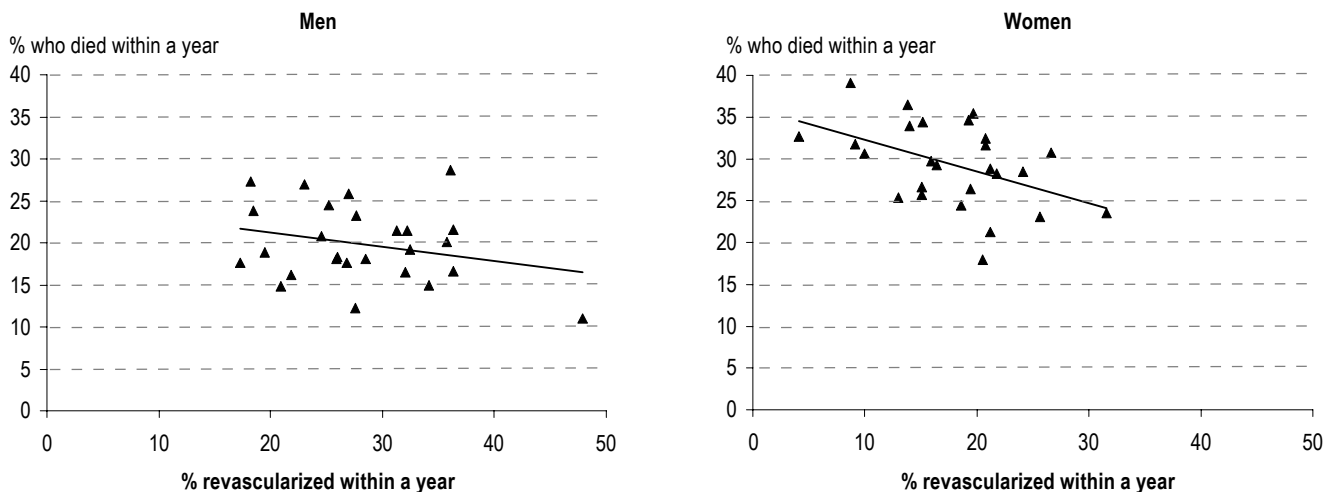† *Less than 100,000 population*
* *p < 0.05*

Calgary RHA counterparts, male AMI patients in the Saskatchewan health regions had an increased risk of dying, as did those in five British Columbia

Chart 5
Percentage of male and female heart attack patients hospitalized between April 1, 1995 and March 31, 1996 who died within a year, by percentage who were revascularized, health regions,[†] four provinces[‡]

Men
% who died within a year

Women
% who died within a year

Data source: Person-oriented Information Database
† 100,000 population or more
‡ Nova Scotia, Saskatchewan, Alberta, British Columbia

Limitations

The one-year period during which patients were tracked is too short to identify everyone who eventually undergoes revascularization. Since the analysis is based on a one-year cohort, 1995/96, it is not possible to generalize the results beyond this period. As well, results for four provinces cannot be used to infer the national situation.

Record linkage in the Person-oriented Information Database was done separately for each province. Thus, a patient with heart attack-related hospital admissions in two different provinces during the same fiscal year would be counted more than once.[21] However, the overall effect of such events is considered small. In fact, because procedures performed outside a patient's province of residence do not always have the health insurance number on the morbidity file, it is more likely that out-of-province procedures could result in an underestimation of the number of residents of a particular province undergoing revascularization.

While adjustments were made to account for co-morbidity, the only data available were those in an administrative data base. Clinical factors such as the site and severity of the AMI and blood pressure and heart rate at admission could not be taken into account. As well, some hospitals may not have coded all co-existing conditions in the discharge abstracts that are the basis for this analysis. On the other hand, it is unlikely that undercoding of co-morbid disease would dramatically alter a hospital's risk-adjusted mortality rate, as demonstrated in a California AMI validation study.[22]

A major limitation of this analysis is the lack of data on risk factors, disease severity, medications and specific treatments, and follow-up information on functional status and morbidity.

The hospital morbidity database does not include people who were revascularized as outpatients. However, other reports have shown that this is a relatively rare occurrence: 92% of PTCAs in the United States[23] and almost all PTCAs in Alberta[24] were performed on inpatients, as were all CABGs in both places.

Revascularization rates in this analysis are not completely accurate representations of the extent of revascularization performed on AMI patients by hospitals in any specific health region. The data are based on the patient's postal code and do not necessarily coincide with the location of the facility where the procedure was performed.

Health regions were identified based on residential postal codes provided by patients on admission and are subject to error. Patients may be unable to provide their postal code or have no fixed address. Such cases are not treated in the same way by all institutions. Some hospitals use the facility's postal code; others use a special value.

The association between revascularization and deaths may be diluted because the mortality figures include all causes of death. Revascularization rates were low among AMI patients with other health problems. However, the co-morbidities may have placed those patients at increased risk of dying from a non-heart health problem within the year.

Except for British Columbia, this analysis is limited to patients who were registered as inpatients, and so does not reflect all AMI deaths. Admissions in British Columbia are based on presentation; that is, when the person first arrives at the facility. British Columbia patients who die in the emergency room (not yet registered as inpatients, but present at the facility) within six hours may be deemed inpatients. This practice varies by facility. The robustness of the models was tested by removing deaths that occurred in less than one day in all four provinces and comparing the results with those reported here. The conclusions that can be drawn from both analyses are similar.

health regions. On the other hand, for female heart attack patients, the risk of dying was significantly high, compared with Calgary, in only one large British Columbia health region.

Allowing for the effects of age, sex, co-morbidity and region, the hazard ratio for dying was low among male patients who had been revascularized. The risk of dying was 27% lower among men who had had a procedure within two weeks than among those who had not been revascularized. For those revascularized at a later date that year, the risk of dying was 34% lower. The difference between these two figures could indicate that patients who are revascularized sooner may have been more urgent cases, and at the same time more seriously ill, in ways that are not well measured by the Charlson Index. Among female heart attack patients, neither early nor later revascularization was associated with the risk of dying.

Concluding remarks

Revascularization is an important treatment option following a heart attack, but not all patients are appropriate candidates. The first consideration is the nature of the blockage and whether it is suitable for angioplasty or coronary artery bypass graft surgery. The second consideration is the patient's age and the presence of co-morbidities that would contraindicate an invasive procedure.

In fact, according to this analysis, most AMI patients are not revascularized. A year after their heart attack, three-quarters of the 12,271 patients admitted to hospital in 1995/96 in Nova Scotia, Saskatchewan, Alberta and British Columbia had not been revascularized. Revascularization tended to be performed less frequently on those who were elderly or who had other conditions, and was more common among men than women.

A key measure of the effectiveness of any procedure is how long patients survive. When age, co-morbidity and health region were taken into consideration, male heart attack patients who had been revascularized were at less risk of dying than were those who had not had such a procedure. Revascularization was not significantly associated with women's chances of survival, possibly a

reflection of the smaller number of women in this analysis.

There was substantial, unexplained variation in rates of revascularization and death among the large health regions of the four provinces. To some extent, this may be associated with factors that vary geographically, but are not available in hospital morbidity or mortality data. Geographical differences in any surgical procedure may reflect the relative importance of professional discretion in the decision to use it; diagnostic and practice styles; and physicians' training, experience and belief in the efficacy of the procedure. Hospital policies, practices and facilities may vary from region to region, as may the severity of heart attack cases. Clinical variables such as arrival time in hospital, use of secondary preventive medications,[25,26] cardiac rehabilitation services, and outpatient care after discharge may also differ by region.[27] In addition, patient characteristics such as smoking and obesity, and whether the individuals subsequently reduced their risk exposure may be influential. Socio-economic status, the availability of social support, and the individual's work environment are well-established health determinants[28-30] that could not be directly examined, but that might be associated with health region.

Geographic variations in revascularization rates within Canadian provinces[31-35] and between Canada and the United States[36-38] are not new and have sparked a debate on the appropriate rate of use of these procedures and raised questions about waiting times.[39-43]

There is no consensus on the optimal rate of revascularization after a heart attack. The greater use of revascularization in the United States does not consistently improve mortality rates,[36,37] although a recent study concluded that American patients experienced a better quality of life than Canadian patients, which might be attributable to more aggressive management based on early coronary angiography and PTCA.[44] As well, a significant excess of angina pectoris with resultant diminished quality of life has been reported for the lower Canadian surgery levels, compared with the United States.[37,38]

The results of this analysis are suggestive, but not definitive. As noted, the data do not contain clinical details on the severity of the AMI or other medical treatments that may have been administered when patients arrived at hospital, information about the facilities or the physicians in those facilities who would make treatment decisions, or information about patient characteristics that would influence those decisions and affect one-year survival. Therefore, this analysis cannot assess whether revascularization rates are too low or too high. ●

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Appendix

Conditions used for Charlson Index

Weight	Condition	ICD-9 code
1	Myocardial infarction	410, 411
	Congestive heart failure	398, 402, 428
	Peripheral vascular disease	440-447
	Dementia	290, 291, 294
	Cerebrovascular disease	430-433, 435
	Chronic pulmonary disease	491-493
	Connective tissue disease	710, 714, 725
	Ulcer disease	531-534
	Mild liver disease	571, 573
2	Hemiplegia	342, 434, 436, 437
	Moderate or severe renal disease	403, 404, 580-586
	Diabetes	250
	Any tumor	140-195
	Leukemia	204-208
	Lymphoma	200, 202, 203
3	Moderate or severe liver disease	570, 572
6	Metastatic solid tumor	196-199