UTILIZATION AND OUTCOMES ASSOCIATED WITH CORONARY ANGIOGRAPHY, CORONARY ARTERY BYPASS SURGERY AND PERCUTANEOUS TRANSLUMINAL CORONARY ARTERY ANGIOPLASTY IN MANITOBA, 1987-1992

by

F. KATHLEEN HARTFORD

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UTILIZATION AND OUTCOMES ASSOCIATED WITH CORONARY ANGIOGRAPHY, CORONARY ARTERY BYPASS SURGERY AND PERCUTANEOUS TRANSLUMINAL CORONARY ARTERY ANGIOPLASTY IN MANITOBA, 1987-1992

BY

F. KATHLEEN HARTFORD

A Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

Abstract

Utilization of, and outcomes associated with, coronary angiography, coronary artery bypass surgery (CABS) and percutaneous transluminal angioplasty (PTCA) in Manitoba from 1987 to 1992 were assessed. Using a longitudinal, observational design and four administrative data files from the Manitoba Centre for Health Policy and Evaluation, Manitobans who had angiography were followed for up to six years to determine: (a) if they had CABS or PTCA, and (b) their survival after these procedures. Histories contained linked files with up to ten hospitalizations. Covariates analyzed included: (a) age, (b) gender, (c) region of residence, (d) income, (e) comorbidities, and (f) waiting time. Kaplan Meier survival curves were calculated and Cox proportional hazard regression analysis was conducted. Results indicated that utilization had shifted to the elderly, and that baseline characteristics of Manitobans were similar to other jurisdictions. Rates had increased for all procedures, with angiography growing the fastest. Advanced age, congestive heart failure and coagulopathies decreased survival. Physicians prioritized patients who required urgent, same day treatment and waiting time did not affect survival. Waiting time may be a proxy for severity of coronary artery disease in administrative databases. Short-term and long-term case fatality rates were similar to other provinces.

DEDICATION

TO MY SON, JAY SCHERER, WHO GREW FROM A BOY TO A YOUNG MAN WHILE I COMPLETED THIS DOCTORATE: MY MOTIVATION.

ACKNOWLEDGEMENTS

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CHAPTER 1

Literature Review

Introduction and Background

While cardiovascular mortality rates have been declining in developed countries since the 1960's, the disease remains the leading cause of death. Newer invasive technologies such as diagnostic coronary angiography, therapeutic coronary artery bypass graft surgery (CABS) and percutaneous transluminal coronary angioplasty (PTCA) have produced changes in the treatment of coronary artery disease (CAD). The issue of whether CABS results in improved short and long-term outcomes over PTCA remains controversial and the results of ongoing randomized clinical trials (RCTs) are quite recent. Even after the results of all trials have been reported, the continued monitoring of secular trends in the utilization of, and outcomes associated with, CABS and PTCA is required. While RCTs can determine the efficacy of procedures, they cannot monitor changes in such variables of interest as: baseline characteristics of patients, risk factors for mortality, length of hospital stay, quality of life and survival rates over time.

To address the question, "Where does Manitoba fit into the results reported to date in the literature?" this study will examine the Manitoba population who had angiography from fiscal years (FY) 1987/88-1992/93. Longitudinal histories will be constructed from the Manitoba Centre for Health Policy and Evaluation (MCHPE) administrative database and patients will be followed for up to six years to determine if they had CABS or PTCA. This chapter highlights the epidemiology of cardiovascular disease (CVD). Three risk factors in the development of CVD, (a) age, (b) gender, and

(c) socioeconomic status, are also important sociodemographic variables associated with utilization and outcomes of CABS and PTCA and are available in the MCHPE database. An indepth review of the literature will be presented concerning the association of these sociodemographic variables on utilization patterns. Further, the influence of these variables and an additional sociodemographic variable, region of residence, and two clinical variables, comorbidities and waiting time, on survival following CABS and PTCA will be assessed.

The influence of age on coronary artery disease (CAD) procedural utilization and outcomes is clear in the literature. A shift to increased utilization in the elderly has been observed and age has been a consistent independent risk factor for increased procedure related mortality. This study will update previous Manitoba work on the impact of age on utilization in CABS and will extend that work to angiography and PTCA. Controversy plagues the literature in regards to the existence of gender bias in the diagnosis and treatment of CAD and this study will examine gender differences in referral patterns in utilization of the procedures. Some investigators have found that gender affects outcomes and that women have less favourable survival; however, other studies have found that controlling for age and comorbidities removes the effect of gender. By examining the entire population of patients who had angiography and then went on to have PTCA or CABS over a six year period of time, the association between gender and utilization and outcomes was assessed in Manitoba.

Testing for the effects of income on utilization and survival was an important contribution to the literature. While the incidence of CAD is inversely related to socioeconomic status (SES), only two studies have examined the effect of income on CABS. One study using administrative data compared effects of income on CABS utilization in two states and three provinces: results differed between the young and the elderly. Manitoba was included in this study. Using a longitudinal design, this study will extend that work by examining the impact of SES on angiography and subsequent therapeutic procedures, CABS and PTCA and on survival after CABS and PTCA.

Geographical variation in procedural rates is widespread between and within countries. Extensive variation in CAD procedures makes this a point of particular interest. Because the majority of the Manitoba population resides in the capital, Winnipeg, while the remainder is widely dispersed over a large land mass, CAD procedures have been centralized in two teaching hospitals in Winnipeg. Regional access to CAD thus becomes an vital issue for review. A previous study found regional variations in CABS utilization with no differences in indicators of the prevalence of IHD; thus, the relationship between region of residence on utilization and outcomes is of continued interest.

While administrative data are typically devoid of clinical variables, two are available for inclusion in this study: comorbidities and waiting time. The inability to assess the influence of comorbidities using administrative data has previously been seen as a major deficiency. This study will use a recently developed CAD-specific comorbidity classification scheme. Comorbidities associated with utilization of the procedures will be described; the impact of comorbidities on survival will be appraised. Since this longitudinal study contains relevant hospitalization histories for up to six years, a unique opportunity is available to describe and assess the effect of waiting time between diagnostic and therapeutic procedures on utilization and outcomes.

This study will determine specific and adjusted CAD utilization rates and diffusion patterns in Manitoba over FY 1987/88-1992/93. Relevant baseline sociodemographic and clinical characteristics of eligible patients, available in the administrative database will be described; the impact of these characteristics on survival was assessed.

Epidemiology of Ischemic Heart Disease

A brief overview of the epidemiology of ischemic heart disease (IHD) or coronary artery disease (CAD), (the terms are interchangeable), is warranted in order to appreciate the contribution of newer coronary artery therapeutic procedures. IHD is a multifactorial disease and it is thought that several mechanism are involved in its pathophysiology. This multiple pathway causation theory fits with the numerous risk factors associated with CAD. Marmot and Mustard (1992) postulate that possibly three processes are involved in the pathophysiology of IHD: (a) atherosclerotic thickening of the lining of the coronary artery vessels which is an asymptomatic process. When muscle spasm in the vessels occurs, angina ensues; angina also ensues when demand exceeds the blood supply which is available through fixed stenosis, (b) focal stenosis and occlusion of the vessels which leads to myocardial infarction, and (c) formation of thrombi at the stenotic areas leading to various coronary syndromes.

Risk Factors

The major biological determinants of IHD can be classified into three groups:

(a) independent, modifiable risk factors or primary risk factors for which there is sufficient evidence using Bradford Hill's (1965) criteria to support a causal pathway. These include: (i) dietary-induced hypercholesterolemia, (ii) smoking, and (iii) hypertension.

(b) independent, non-modifiable, primary risk factors which include: (i) age, (ii) gender, and (iii) family history of premature coronary heart disease.

(c) secondary, modifiable risk factors, that is those risk factors for which there is strong evidence of an indirect association: (i) obesity and (ii) diabetes. Physical inactivity is a modifiable secondary risk factor where the evidence is less conclusive, but for which there seems to be consensus among practitioners.

The most prevalent psychological determinant of IHD under investigation is Type A behaviour pattern (TABP). In evaluating studies on TABP using Hill's (1965) criteria for causality, the conflicting evidence does not allow concluding that TABP meets the criteria as an independent risk factor for IHD across populations.

Three social determinants of IHD dominate the literature: (a) job strain, (b) social supports, and (c) social class. Job strain is an intriguing operationalization of external stress and while current evidence would support the indirect association between job strain and IHD in industrialized countries, there is insufficient evidence to report that it is a direct and independent risk factor. Similarly, inconsistent findings do not allow stating that the absence of social networks and social contacts are independent risk factors for IHD and more research is required. Social class analyses examine the way in which the organization of society effects health and disease. The construct, social class, is operationalized in several ways, i.e., education, race, income, and meets Hill's (1965) criteria as an independent, modifiable risk factor for IHD. The link between social class, social network and job strain is fertile ground for future research; leaders in the field postulate that "...it is likely that psychological work conditions constitute an important part of the association between social class and cardiovascular disease risk" (Marmot & Theorell, 1988).

Mortality

The decline in CVD mortality seen in developed countries is thought to be related to a real decline in incidence, rather than a decrease in case fatality rates due to improved hospital care. This decline is thought to be genuine, rather than just a shift in diagnostic or coding practices, because it is accompanied by a corresponding decline in all cause mortality. In Canada, CVD mortality declined by 42% in males and by 58% in females between 1951 and 1987. Currently there is an annual decline in CVD mortality of 3% for both sexes. None the less, in 1987, CVD accounted for 42% of all deaths in all age groups. In spite of the real decline in CVD age-standardized death rates, CVD has been the leading cause of death in Canada since the 1920's and remains the leading cause of death and hospitalization for persons aged 35 and over (Nair, Nargundkar, Johanson & Strachan, 1990).

Morbidity

CVD accounts for 25% of all disability pensions paid before age 65 by the Canada Pension Plan. Although CVD mortality is declining, the disease remains the major cause of hospitalization "...accounting for 8.3 million patient days in 1985. At over $350 per day of hospitalization (low estimate), this represents a cost of over $3.0 billion, not including doctors fees and costs of surgery, etc." (Nair, Colburn, McLean & Petrasovits, 1989, p. 17). From 1981 to 1987, the absolute number of hospitalizations for IHD in 12 census metropolitan areas (CMA) rose by 22% even though the rate increased at a slower pace, 6%. If primary and secondary prevention strategies are related to a decreased incidence of CVD one would expect to see both a decline in mortality and hospitalization. Newer diagnostic and therapeutic procedures and the application of these procedures to the elderly have been implicated in the increased hospitalizations in the face of declining incidence.

This brief overview of the epidemiology of IHD has been presented in order to set the stage for this study's examination of the utilization and outcomes associated with procedures for the diagnosis and treatment of IHD. Risk factors for development of IHD may continue to exert an influence on the circulatory vessels after the disease becomes manifest and after treatment is underway.

Effects of Sociodemographic Variables on CABS and PTCA Utilization

The literature concerning four major sociodemographic variables associated with the utilization of two coronary artery revascularization procedures, CABS and

PTCA, will be reviewed. The rationale for their inclusion in the study will be discussed. The variables are: (a) age, (b) gender, (c) socioeconomic status as a measure of social class, and (d) region of residence as a measure of geographical variation.

Age. Demographics have changed in industrialized societies and seniors constitute the most rapidly growing age group; this in turn, has led to increased utilization of health care resources by the elderly. "Because the elderly constitute an increasing proportion of Canada's population, their high rates have major implications for demands on health services" (Nair et al. 1990, p. 206). From FY 1979/80 to 1988/89, the proportion of the population aged 65 years and older increased from 9.6% to 11.3% in Ontario and utilization of services in the elderly related to circulatory disease also increased (Anderson & Pulcins, 1991). The overall hospital separation rate during that time period for diseases of the circulatory system increased by 3%; the medical separation rate increased by 2% and the surgical by 12%. The surgical separation rate increased among patients aged 55 to 79, but decreased in all other adult age groups. While there was a 50% increase in CABS rates, it decreased among patients under 55 years and increased among those over 55, especially in those over 70.

Increased IHD utilization in the elderly has been noted in both Canada and the United States (Anderson, Newhouse & Roos, 1989). In two provinces and the U.S., medical and surgical hospital discharges were compared in the elderly during FY 1981/82 and FY 1985/86. In both countries, the case-mix units per 100,000 persons were similar and medical cases accounted for 85 - 90% of discharges. While surgical rates rose in both countries, a disproportionate increase occurred in the U.S., 64% between FY 1981/82 and FY 1985/86. Doubling of valve and bypass surgery occurred in the U.S. while in Canada, valve surgery increased by 20% and bypass by 86%. The fastest rate of CABS growth was in the 75 and over age group; there was a threefold growth in the U.S., while the rate doubled in Canada.

The sudden increase in CABS is thought to be due to expanded use of the procedure in the elderly. In the U.S., the crude number of CABS rose gradually from FY 1979/80 until FY 1987/88, and in that year the numbers rose by 45%. The rate of CABS in women is about two-thirds that in men, until age 75 when the rates become equal. Age-adjusted rates in blacks are one half of those in whites (Leape et al. 1991). In both Canada and the U.S., age-specific CABS rates are higher for men than for women, and in Canada this gender difference has remained in the elderly. The greatest area of growth in CABS rates in both sexes is in the 65-74 age group, followed by the 75 and over age group. Rates have remained stable in the 55-64 age group and actually declined in the 35-54 age group (Peters, Changani, Paddon & Nair, 1990).

> Coronary artery disease incidence appears to be falling, or at least migrating to the later stages of life; prevalence is not falling, due to lower death rates from the disease at all stages. However, the shift to more elderly patients undergoing CABS far outstripped that which would be expected from changes in patterns of underlying disease. (Naylor, 1991, p. 115).

In Canada, the crude number of CABS increased from 31.1 per 100,000 in FY 1981/82 to 43.2 per 100,000 in 1987/88 (Naylor, Ugnat, Weinkauf, Anderson & Wielgosz, 1992). The greatest increase, 16.1%, occurred in FY 1983/84, while a 2.2% decrease occurred in FY 1985/86. The decline is thought to reflect the introduction of PTCA as an alternative procedure for less severe forms of CAD. The decline is also typical of the diffusion pattern of a new technology, with rapid early growth followed by plateaus or decreases. In Ontario, where CABS is regionalized, rates increased by 39% from FY 1979/80 to FY 1983/84. The proportion performed in the over 65 population rose from 12.8% in FY 1979/80 to 27.4% in FY 1985/86 and accounted for over half the increase in CABS; the rate increased more than five-fold in the 70 and older group. Since mortality from IHD and admissions for AMI are decreasing in Canada, Anderson and Lomas (1988) did not believe that changes in the prevalence of CAD could explain the rapid increase in CABS rates. Regionalization has not controlled the diffusion of CABS in Ontario, although it may have slowed it. From FY 1981/82 to FY 1989/90, the overall CABS rate was 2.6 time higher in those 65 and older (Ugnat & Naylor, 1994). This increase has been interpreted as due to a more aggressive treatment style and also that the effects of primary prevention have not yet been realized in the elderly cohort.

CABS rates in Manitoba mimicked those in other jurisdictions. Between FY 1980/81 and FY 1983/84, CABS rates doubled for men aged 45-74 and for women aged 55-74; the sharpest rise was in the over 75 age group (Roos & Sharp, 1989). Changes in age-specific rates did not correspond to changes in demographics as there were shifts in utilization across all age groups. However, the decreased utilization by the younger cohort could continue to decline in the future if the current rate actually reflected decreased incidence due to primary and secondary prevention.

While the original PTCA guidelines suggested that the procedure should only be performed on patients under 60 years of age, the benefit of PTCA in the elderly soon became apparent. Although Hilborne, Leape, Kahan, Park, Kamberg and Brook (1991) noted that several observational studies had reported primary success rates of 90% in the elderly (Hartzler, Rutherford, McConahay, Johnson & Giori, 1988; Bedotto et al. 1991), no RCTs comparing PTCA with medical therapy in the elderly were located. The number of PTCAs in the U.S. grew by 1,220% between FY 1983/84 and FY 1990/91; in FY 1990/91 more than 400,000 procedures were performed. The utilization rate of both procedures had a dramatic increase, from 200,000 CABS in FY 1984/85 to 300,000 in FY 1986/87 and from 200,00 PTCA in FY 1988/89 to 400,00 in FY 1990/91. In FY 1988/89, the number of PTCAs and CABS performed were equivalent but by FY 1991/92, the number of PTCA exceeded that of CABS. Originally PTCA was intended to be an alternative to CABS but since the indications for CABS have narrowed, it is apparent that PTCA is no longer an alternative but an adjunct therapy. The dramatic growth rate is again due to increased utilization in the elderly.

This thesis contributes to the literature which reflects a shift to increased coronary artery procedure utilization in the elderly by updating the previous work on age-specific utilization rates in Manitoba from FY 1987/88-1992/93 and by extending this analysis to angiography and PTCA. Administrative databases are particularly suited to answering the question: "Have the age-specific utilization rates changed over the study period?"

Gender. The protective effect of estrogen results in a ten year delay in the manifestation of CVD in women (Stampfer et al. 1991). Women with CVD present differently than men (Wenger, Speroff & Packard, 1993) and their pattern of angina symptoms is distinctive (Wenger, 1990). A higher proportion of acute myocardial infarctions (AMI) in women are fatal and reinfarction rates in women are higher (Lerner & Kannel, 1986). While these rates could be related to age differences, Orencia, Bailey, Yawn and Kottke (1993) found that post-AMI survival rates and risks of reinfarction were no different for women than for men of similar age. Some investigators (Bickell et al. 1992; Vacek, et al. 1993) have found that the gender differences in utilization rates represented appropriate diagnosis (Mark, Shaw, DeLong, Califf & Pryor, 1994) and treatment, while others question whether underutilization in women and overutilization in men occurs (Ayanian & Epstein, 1991). On balance, gender bias is supported by current studies. Women are less likely than men to be referred for non-invasive ischemic testing by non-cardiologists (Jaglal, Slaughter, Baigrie, Morgan & Naylor, 1995) less likely to be referred for angiography (Steingart et al. 1991;) and are referred later in the course of their disease (Tobin, Wassertheil-Smoller, Wexler, Steingart, Lense & Wachspress, 1987). They are also less likely to be referred for CABS (Khan, Nessim, Gray, Czer, Chaux & Matloff, 1990; Naylor & Levinton, 1993; Jaglal, Goel & Naylor, 1994) and PTCA (Krumholz, Douglas, Lauer & Pasternak, 1992). This systematic difference in referral patterns for diagnostic and therapeutic procedures has been found in North America and the U.K. (Petticrew, McKee & Jones, 1993). Exercise testing is also a less reliable predictor of CAD in women (Laskey, 1992; Mark, Shaw, DeLong, Califf & Pryor, 1994). More males than females have CABS after diagnosis of CAD (Becker, Corrao & Alpert, 1988).

Because this longitudinal study uses population-based, administrative data it is well posed to contribute to the literature on gender differentials in referral patterns for CAD procedures in an entire province over a prolonged period of time. However, this thesis is not designed to assess the appropriateness of the procedures between the genders: a retrospective chart audit would be best suited to such an objective.

Socioeconomic Status. Income differences in the manifestation of CVD are reported in the literature but few studies have examined the influence of socioeconomic status (SES) on revascularization utilization patterns. Using insurance coverage as a proxy for SES, the effects of Medicaid cost containment policies implemented in FY 1983/84 on CAD patients in non-federal hospitals in California were examined for FY 1983/84, 1985/86 and 1988/89 (Langa & Sussman, 1993). Rates of revascularization were similar in FY 1983/84 for the three insurance groups: (a) Medicaid, (b) fee-for service, and (c) Health Maintenance Organizations (HMO) but increased more rapidly over the course of the study in fee-for-service and HMO patients than in Medicaid patients. While insurance coverage and public and private hospitalization are often proxies for SES in the U.S., Yedidia (1992) found that insurance status was not accurately recorded in the chart. Patients with confirmed AMI or unstable stable angina admitted to a voluntary hospital or its public affiliate were followed. Both hospitals shared medical interns, residents and fellows. Three times as many patients in the voluntary hospital had cardiac catheterization; for those who didn't have angiography more patients from the voluntary hospital had exercise stress tests ($p < .05$).

Information on household income is available from Canadian and American census data. A comparative study between Canada (Ontario, Manitoba and British Columbia) and the U.S. (New York and California) examined the relationship between CABS and income for FY 1983/84 and FY 1989/89. Patients under 65 years of age living in the poorest areas in three provinces (Ontario, Manitoba and British Columbia) had the highest CABS rates, while an income-utilization gradient was found in California and New York. In the elderly, income utilization patterns were more complex. An income gradient was found in New York; in California, those living in the poorest area had the lowest rates, but rates were similar for all other quintiles. In Canada, patients living in the two highest quintile areas had higher rates, while those living in the three lowest areas had similar, but lower rates (Anderson, Grumbach, Luft, Roos, Mustard & Brook, 1993). Caution should be exercised in interpreting the data. Because this data is aggregated at the neighbourhood census tract level and then at the CMA level, it is prone to the ecological fallacy if applied to individuals. This thesis will extend the

Anderson paper by examining the effect of income, as measured by household income from Statistics Canada's 1989 census, on referral patterns for CAD diagnostic and therapeutic procedures. Administrative data lends itself to the calculation of income-adjusted utilization rates because of the ease with which census data can be linked to it.

Region of Residence. Geographical variation in rates (Wennberg, 1984) has long been a focal area for study and the predominant explanation cited is differences in practice patterns due to medical uncertainty. Evidence-based health services research is attempting to fill the uncertainty void by conducting meta-analyses and studies with more rigorous design and larger sample sizes. Variation in rates occurs among and within countries. Focusing on CAD procedures, the U.S. has the highest CABS rates; the FY 1986/87 rate of 95.3 per 100,00 was twice that of Canada and all of Europe (Naylor, Ugnat, Weinkauf, Anderson & Weilgosz, 1992). In FY 1987/88, the CABS rate per 100,000 was 41.8 in Canada and 138.3 in the U.S. but the IHD age-standardized mortality rates did not reflect such differences (Nair et al. 1990). "In 1988 PTCA was performed in the U.S. at a rate of 1,000 per million population as compared to 390 in Belgium, 256 in Australia and 233 in Germany" (Topol et al. 1993, p.12). Geographical variations in PTCA within the U.S. were noted in Topol's study of young, employed, insured Americans.

Age-standardized CABS rates for 12 CMAs in Canada indicated marked variation with the mean rate per 100,000 ranging from a low of 62.4 in Halifax to a high of 131.8 in Ottawa-Hull. Whether the variations in CMA rates indicate over or underutilization or true variation in disease incidence is not known (Peters, Changani, Paddon, & Nair, 1990). Because CABS rates in Canada were noted to be lowest in Alberta, regional variation in CABS utilization was studied in that province (Platt, Svenson & Woodhead, 1994). The rate did not vary across 19 census divisions in Alberta for a cohort of all individuals registered for health care insurance on April 1, 1984 and followed for five years. Anderson and Lomas (1988) examined CABS rates in Ontario and noted substantial variation in rates by county of residence.

In Manitoba, where cardiovascular surgery is aggregated at the two Winnipeg teaching hospitals, Roos and Sharp (1989) examined the effect of centralization on angiography and CABS regional rates between FY 1977/78 and FY 1983/84. Except for the years 1980/81-1981/82, rates were higher for Winnipeg residents. Western Manitoba residents consistently had lower angiography and CABS rates. Using AMI as an indicator of IHD, correlations between hospitalization for AMI and AMI mortality were low and nonsignificant ($r = .17$). Other indicators of health status were examined and no significant regional differences were found. Patients from Western Manitoba who were referred for angiography differed from patients from other regions in that they had symptoms longer than three months. Other within-region surgical rates did not differ for Western Manitobans, indicating that the strongest hypothesis for CABS variation was physician reluctance to refer. Thus, the inclusion of variation in regional utilization between FY 1987/88 and FY 1992/93 is of continued interest in this thesis. A major contribution of administrative data to the health care literature has been small area utilization analysis.

Effects of Sociodemographic Variables on CABS and PTCA Mortality

Efficacy of CABS over medical therapy

Leape and associates (1991) reviewed the CABS literature published until 1990 while Johansson, Brorsson & Bernstein (1994) updated the review to March 1993. A dominant question was whether CABS was more effective than medical therapy. The RCTs examined were: (a) the Coronary Artery Surgery Study (CASS, 1983), (b) the Veterans Administration (VA) Cooperative Study (1984), and c) the European Coronary Surgery Study (ECSS, 1982). In comparing CABS to medical therapy, the VA and ECSS studies found statistically significant gains in survival only in patients with three-vessel or left main disease; the ECSS also found significant differences in patients with two-vessel disease involving the left anterior descending (LAD) artery. Although the CASS study excluded patients with left main disease, no differences in survival were found among any groups. CASS patients had milder disease and improved medical therapy which may account for the diverse findings. Yusuf and colleagues (1994) reviewed seven RCTs that compared medical therapy with CABS in patients with stable angina; CABS patients experienced lower mortality rates after ten years of follow-up. Limitations of these studies include the fact that major changes in medical and surgical therapies have occurred since enrolment between FY 1972/73 and FY 1979/80. For example, the RCTs were conducted when saphenous vein grafts were used; currently the internal mammary artery, which occludes less often, is used in CABS. The average age of patients was 49-53 years with CASS and ECSS limited to patients under 65. The CASS study was the only one to included women and they represented merely 10% of the study population.

<u>Efficacy of CABS over PTCA</u>

Hilborne, Leape, Kahan, Park, Kamberg and Brook (1991) reviewed the PTCA literature from 1980 to 1990 and Johansson and associates (1994) updated the review to March 1993. While 13 RCTs were included in the earlier review, none were designed to compare CABS and PTCA. However, recent RCTs have reported on short and long term efficacy. Equivalent short-term efficacy of CABS and PTCA in multivessel disease was noted in the German Angioplasty Bypass Surgery Investigation (GABI) RCT which compared the effects of CABS and PTCA on angina one year post-procedure (Hamm, Reimers, Ischinger, Rupprecht, Berger & Bleifled, 1994). CABS patients took fewer anti-anginal medications and had fewer repeat procedures. Currently there are five RCTs underway to assess the long-term efficacy of PTCA and CABS. The first of these RCTs, the Randomized Intervention Treatment of Angina (RITA) study of more than 1,000 patients, found no differences in mortality or AMI and similar improvements in exercise capacity after 2.5 years of follow-up. However, PTCA patients were more likely to have persistent angina, to need more anti-anginal medications and to require repeat revascularization (RITA Trial Participants, 1993). Similar results were reported from the ERACI trial in the Argentine (Rodiquez, Boullon, Perez-Balino, Pavriotti, Liprandi & Palacios, 1993). The Emory University Angioplasty versus Surgery Trial (EAST) recently reported that after three years of follow-up, 392 patients who were randomly assigned to PTCA or CABS had no post-procedural differences in AMI or angina. Differences in arterial patency were found with 66% of CABS patients achieving complete revascularization as opposed to 44% of PTCA patients. More PTCA patients required repeat revascularization than did CABS patients. Since the mortality rates were similar, PTCA was seen as a viable alternative to CABS (King et al. 1994).

Mortality and risk factors for mortality

Mortality can be defined as: (a) operative mortality, which is usually expressed as 30 day mortality rates or case fatality rates and (b) survival, that is, longer term mortality. There are four major classes of risk factors for operative mortality: (a) clinical factors including sociodemographic variables, (b) anatomical risk factors, (c) physiological factors, and (d) operative factors. Leape and colleagues (1991) found that six CABS mortality risk factors consistently emerged over a number of studies: (a) congestive heart failure (CHF), (b) age, (c) female gender, (d) left main stenosis >90%, (e) emergency operation, and (f) number of operative vessels. Excluding CHF and female gender, the relative risk of these factors has declined since the 1970's. Tu, Jaglal and Naylor (1995) identified six risk factors for CABS mortality, length of stay in intensive care, and hospital length of stay in a FY 1991/92-1993/94 study of all CABS patients in Ontario. They were: (a) age, (b) gender, (c) left ejection function, (d) type of surgery, (e) urgency of surgery, and (f) repeat operation. Johansson (1994) identified: (a) age, (b) female sex, and (c) left main disease as associated with increased risk for

PTCA mortality. Of all the operative mortality risk factors, MCHPE administrative data contains information on the following: (a) age, (b) gender, (c) region of residence, (d) socioeconomic status, (e) comorbidities, and (f) waiting time. Where available, the literature on the impact of these variables on CABS and PTCA mortality will be reviewed.

Lacking RCTs, historical cohort analysis had been used to compare the differences in outcomes between CABS and PTCA patients. Many studies found differences in long-term survival between CABS and PTCA, although in some studies these differences were not significant at three years (Hochberg, Gielchinsky, Parsonnet, Jacobs, Bradbury & Chae, 1989) or could be accounted for by age and ejection fraction (Akins, Block, Palacios, Gold, Carroll & Grunkemeier, 1989). In general, the life-time experiences of CABS and PTCA patients are different. Long-term freedom from AMI is superior in CABS and CABS patients are less likely to undergo repeat revascularization. While PTCA patients have lower hospital costs "...the event-free survival was significantly different, the surgical patients doing better than the angioplasty patients" (Kramer, Proudfit & Loop, 1989, p. 1,153).

Long term differences in event-free survival are superior in CABS patients because of the repeat revascularization associated with PTCA. Observation studies have identified that operative mortality differs between CABS and PTCA patients. Overall CABS operative mortality in the 1980's ranged from 0.9 to 4.4% and complication rates ranged from 1-5%. Operative mortality declined by 33% between 1970 and 1980 in spite of the increase in the proportion of higher risk patients. The decline is attributed to technical advances and improved skills of providers. PTCA mortality rates in large series were consistently around 1% in the 1980's, despite the trend towards the selection of more complex, high risk patients (Hilbourne et al. 1991).

Cameron and colleagues (1994) questioned whether the greater morbidity and longer rehabilitation associated with CABS was countered by the repeat revascularizations connected with PTCA. A retrospective review of 358 patients undergoing initial CABS or PTCA for confirmed stenosis of the left anterior descending (LAD) artery was conducted. Minor differences in LAD disease severity were noted but patients did not differ on other sociodemographic or clinical characteristics. No differences in mortality, quality of life or functional ability were found but PTCA patients required more frequent revascularizations. A retrospective study of the effectiveness of CABS and PTCA was conducted comparing a national dataset from 1985 of all Health Care Financing Administration (HCFA) Medicare data with a random sample of charts from seven peer review organizations (Hartz et al. 1992). The MedisGrps (Brewster, Karlin, Hyde, Hussain, Mursky & Fisch, 1985) severity scoring system was used to abstract the charts. Using the claims data, thirty day and one year mortality rates were 3.8% and 8.2% for PTCA and 6.4% and 11.8% for CABS. Using the chart data, after eliminating patients admitted with an AMI, 30 day and one year mortality rates were 1.9% and 6.0% for PTCA, and 5.1% and 10.8% for CABS. Differences in PTCA and CABS populations were found with CABS patients having a 2.4 odds of having a high risk MedisGrps severity score. Patients were more likely to have PTCA if they had single-vessel disease, previous revascularization, were female or had elevated prothrombin times. CABS patients appear to have been at greater risk of mortality than PTCA patients because they were at greater risk of mortality before the procedure. Patients were divided into high and low risk subgroups; there were no significant differences in one year survival between CABS or PTCA in the high risk group. In the low risk group, PTCA patients had a statistically significant higher survival rate than CABS patients. Regression analysis identified 13 risk factors associated with mortality; most risk factors are not available from discharge abstracts. After adjusting for covariates, CABS patients had a higher risk ratio (RR) of mortality than PTCA patients, (RR = 1.72). The RR for low risk patients was higher, RR = 2.15, because of the higher risk ratio for CABS during the first 60 days. These mortality rates are higher than those reported in many published studies from academic centres because the latter are usually efficacy studies in which the procedures have been performed on patients selected using strict inclusion criteria.

Lubitz, Gornick, Mentnech and Loop (1993) examined unadjusted Medicare data from HCFA from October 1986 to June 1987 (N = 28,817). The overall in-hospital and 1-year mortality rates were 2.8% and 7.2% for PTCA and 5.7% and 9.7% for CABS. The age-adjusted rates were higher for women than men and lower for blacks than whites. For those 75 years of age and over, the overall in-hospital and 1-year mortality rates were 5.0% and 11.7% respectively for PTCA and 8.6% and 14.3% respectively for CABS. Rehospitalization rates for both index PTCA and CABS patients were significantly higher for female and black patients. Of all patients, 49.8% of PTCA and 57.6% of CABS patients survived a year without rehospitalization for any reason.

New York State has a PTCA registry (Hannan, Arani, Johnson, Kemp & Lukacik, 1992). Examining 5,827 patients between January 1 and June 30, 1991, 35% were 65 years of age or older, 30% were women, and 85% had single-vessel disease. The mortality rate for patients with two-vessel disease was nearly twice (0.91%) that of patients with single-vessel disease (0.56%). Four variables were associated with higher probabilities of in-hospital death: (a) female gender (Odds Ratio (O.R.) = 2.45), (b) hemodynamic instability (O.R. = 24.93), (c) shock (O.R. = 67.63), and (d) lower ejection fraction (O.R. = 0.93).

This study used a retrospective, longitudinal design to follow the entire population of patients who had angiography and proceeded to CABS or PTCA in Manitoba for up to six years. The use of administrative data with its coverage of the entire population enables the operative mortality rates for CABS and PTCA to be described and secular trends noted. The longitudinal design and the MCHPE registry which tracks coverage enables analyses using the Cox proportional hazards regression model to identify the variables associated with differences in survival. In particular, the difference in survival between CABS and PTCA patients will be assessed, although the design does not allow for comparability of the two groups.

The literature on the influence of four sociodemographic variables on CABS and

PTCA mortality rates will be reviewed. As well, the effect of two clinical variables comorbidities and waiting time, on survival will be reported. It is acknowledged that this observational study lacks the rigour of an RCT and that other sociodemographic and clinical variables not contained in the database may account for differences in survival. However, this study allows for the provincial experience associated with the procedures over a six year time frame to be assessed. While not addressing efficacy, vital questions such as "What has happened to CABS rates since the introduction of PTCA in Manitoba?" and "How do Manitoba CABS and PTCA mortality compared to other jurisdictions?" and "Are there systematic age, gender, income or regional differences in the utilization of CAD procedures in Manitoba?" will be addressed.

Effects of age and gender

Utilization of CABS and PTCA has shifted towards the elderly and the efficacy of CABS in 222 patients 75 years and older between January 1977 and December 1986 at a teaching hospital in Boston was assessed. Overall hospital mortality was 10.8% and ranged from 3.6% for elective procedures to 35% for emergency surgery. The actuarial probability of survival at 48 months was 75% compared to 90% for patients less than 75 (Horvath, DiSesa, Peigh, Couper, Collins & Cohn, 1990). Mohan, Amsel and Walter (1992) reviewed the literature on 21 studies in which at least 100 elderly patients had CABS; advancing age was an independent predictor of operative mortality in only five studies. Rather operative mortality was increased in the elderly who had unstable angina, evolving AMI and urgent or emergent status. Long term survival varied but was generally good, i.e. in one study at two years follow-up, survival was 90% and at eight years was 61%. A more recent study (Hartz et al. 1992) examined the mortality rates of 357,885 CABS and 225,915 PTCA Medicare beneficiaries from 1987 to 1990. While PTCA and CABS rates increased by 55% and 18% respectively, 30 day unadjusted mortality rates for PTCA decreased by 25% and for CABS by 12% and one year rates for PTCA decreased by 10% and for CABS by 8%. Adjusted mortality rates decreased by even greater percentages. It is suggested that even though the elderly have more comorbid conditions and acute diseases this is more than balanced by: (a) a volume outcome relationship, (b) better medical management after the procedure, and (c) technological improvements in the procedures (Peterson et al. 1994). An analysis of 3,000 PTCA patients, 474 of whom were aged 75 years and older, was conducted in a Washington State hospital. Age 65 and over was the most important independent risk factor for in-hospital mortality and non-fatal AMI; female gender was almost as important. Operative CABS mortality increases with advancing age; the RR rises from 2.5 at age 65 to 5.3 at age 70 (Leape et al. 1991). Not age, per se, but the more severe CAD and more frequent comorbidities is thought to affect the complications (Lindsay, Reddy, Pinnow, Little & Pichard, 1994).

In-hospital mortality rates for women undergoing CABS and PTCA are higher than for men and Weintaub, Wenger, Jones, Craver and Guyton (1992) postulated that more severe disease in women accounts for these differences. Greater technical difficulties due to smaller coronary arteries in women had been implicated in the differences in mortality rates, but Khan et al. (1990) speculate that more severe CAD is responsible. A 10 year observational study (1980-1990) of initial, elective PTCA patients found that the higher in-hospital and five year mortality rates experienced by women were explained by their older age at the time of the procedure (Weintaub, Wenger, Delafontaine, Morris, Liberman & Douglas, 1992). In-hospital PTCA mortality in women increased and remained higher than in men between FY 1979/80 and 1990/91 at the Mayo Clinic; older age and more severe disease in women accounted for these findings (Bell, Holmes, Berger, Garratt, Bailey & Gersh, 1993). Although women present at an older age and with more advanced CAD, a recent study found no differences in patency rates, complications or in-hospital mortality; technical advances and increased operator experience were cited (Moran, Laramee, Gordon & Davies, 1992).

The current study describes the age and sex-adjusted CABS and PTCA operative mortality rates in Manitoba over a six year time period. Using the Cox proportional hazards regression model, the independent effects of age and gender on survival was determined.

Effects of socioeconomic status

Williams and associates (1992) conducted a prospective cohort study to determine whether the poorer prognosis of those with lower levels of economic and social support was related to more extensive underlying CAD or to the effect of the SES variables themselves. A cohort of 1,368 patients who presented at Duke University for their first angiography with a diagnosis of stable angina and who were found to have significant CAD (>75% stenosis of at least one major coronary artery) were assembled. They completed a baseline economic status and social support questionnaire and were followed at 6 and 12 months post-catheterization and annually thereafter from FY 1974/75 to 1980/81. Disease severity was controlled for by use of a hazard score derived from Cox proportional hazard regression analysis of the survival of the entire population of medically treated CAD patients at Duke over a 15 year period. No significant differences in baseline characteristics were noted. For the study patients, separate economic and social models were fitted using survival analysis. "The additional effect of social and economic deficits was significant, contributing 12% of the total prognostic information about these patients" (Williams et al. 1992, p. 523).

Hadley, Steinberg and Feder (1991) investigated the relationship between insurance status and in-hospital mortality using administrative data on 500,000 patients in a national sample of hospitals; CABS was one of the procedures studied. Except for white women aged 35-49, the uninsured had a higher probability of in-hospital death: for ten of the age-race-sex cohorts, the differences was statistically different.

In Canada, changes in mortality by income were tracked in urban areas between 1971 and 1986 (Wilkins, Adams & Brancker, 1991). Twenty five census metropolitan areas (CMAs) in Canada, representing 60% of the total population, were studied. The Canadian Mortality Database was used to identify deaths for all residents in the CMAs except those in health care institutions. Income was obtained from the total economic family income in private households for the census years of 1970 and 1986. Each census tract within the CMA was ranked into quintiles according to the percentage of the population below Statistics Canada's low income cut-off point. Quintile 1 represented the poorest and Quintile 5, the wealthiest. The study found that the poorer the neighbourhood, the shorter the life expectancy of its residents. Infant mortality in Quintile 1 was twice as high as in Quintile 5. While over the study period, mortality declined in all quintiles, the relative differences between quintiles stayed the same. Between the ages of 45 and 74 years, 39.8% of the total excess Potential Years of Life Lost (PYLL) due to circulatory diseases was related to differences between Quintile 1 and Quintile 5. Nair and associates (1989) noted that CVD mortality rates are significantly higher in lower income groups.

These studies provided the impetus to examine whether income effects CABS and PTCA mortality rates in Manitoba. Using income data at the enumeration area (EA) level from the 1989 census, this thesis examines the income quintile-adjusted CABS and PTCA mortality rates; as well income quintiles were entered into the survival analyses to determine if income effects survival after index CABS and PTCA.

Effects of regionalization

Mortality rates vary between countries; in FY 1990 the crude, all-cause mortality rate per 1,000 was 7.3 in Canada and 8.6 in the U.S. (Nair, Karim & Nyers, 1992). In FY 1988, the CVD mortality rate was 329.6 per 100,000 in Canada, 422.7 in Germany, 214.9 in Japan, 429.7 in the U.K. and 369.2 in the U.S. (Collins-Nakai, Huysmans &

Scully, 1992). Access to cardiovascular services has been speculated as one cause of the variations in CVD mortality rates. In FY 1989/90, the IHD age-standardized mortality rate per 100,000 were 241.5 and 117.8 for males and females respectively in Canada and 254.9 and 137.9 in the U.S. (Nair et al. 1990).

The case for regionalization of CAD procedures was supported when it was noted that in-hospital mortality rates for CABS had declined steadily in large centres due to the improved skill level of the surgical team. The volume-outcome relationship in CABS was noted by Showstack, Rosenfeld, Garick, Luft, Schaffarzick and Fowles (1987) in a study of 77 hospitals in California in 1983. Teams that performed 150 CABS or more per year and hospitals which annually performed 350 or more were associated with significantly better in-hospital survival for emergency and scheduled CABS, lower length of stay (LOS), and potentially lower costs, suggesting that regionalization of CABS is cost-effective. This hospital-volume mortality relationship was also found for PTCA and has been cited as support for regionalization (Jollis et al. 1994).

Inter-state variations in CABS mortality have been documented. In New York State, only 30 hospitals are certified to perform open heart surgery and this constitutes a type of regionalization. A 1989 study identified a hospital-volume CABS mortality relationship and a physician-volume mortality relationship (Hannan, O'Donnell, Kilburn, Bernard & Yazici, 1989) that held even when controlled for clinical risk factors (Hannan, Kilburn, Bernard, O'Donnell, Lukacik & Shields, 1991). The New York State CABS registry identified a surgeon-volume mortality relationship (Hannan, Kilburn, O'Donnell, Lucacik & Shields, 1990) and a hospital-volume mortality relationship (Hannan, Kilburn, Racz, Shields & Chassin, 1994).

None of the studies cited examined the issue of accessibility associated with regionalization. Manitoba has centralized CAD procedures in two teaching hospitals in Winnipeg. Using region of residence as the indicator of regionalization, this thesis examines whether geographical variations found in a previous study (Roos & Sharp, 1989) persist and if so, whether they lead to regional differences in survival. Further, region of residence was entered into the survival analyses to determine whether the covariate was a predictor of decreased survival. It should be noted that this study cannot assess whether regional differences, if found, are attributable to other factors such as, severity of CAD, inappropriate utilization or referral to low volume surgeons.

Effects of Clinical Variables on CABS and PTCA Mortality

Introduction. In contrast to clinical databases which contain abundant data related to operative mortality and long term survival, administrative databases contain minimal clinical information. However, two pertinent variables, comorbidities and waiting time, are available and their impact on mortality reported in the literature will be reviewed.

Comorbidities. Adjusting for the influence of patient characteristics, such as the presence of pre-existing disease, is important in order to make valid inferences about differences in outcomes. Risk-adjusted measures of mortality have become prominent since HCFA began publishing hospital-specific mortality rates for Medicare beneficiaries. However, several issues require attention when adjusting for comorbidities. The first issue is the data source used. When comorbidities are obtained from administrative data, they are less prevalent than when collected from primary data (Romano, Roos, Luft, Jollis & Doliszny, 1994). The prevalence of clinical risk factors in CABS patients at two sites with primary clinical data and two sites with administrative data were compared and were found to differ significantly among sites ($p < .05$). Certain asymptomatic, chronic conditions were less prevalent in administrative databases, while diagnoses such as diabetes, unstable angina and CHF were recorded with similar frequency in administrative and clinical databases. Bias in risk ratio estimates associated with administrative data ranged from 80% underestimation to 35% overestimation.

The second issue is the selection of relevant comorbidities available in administrative databases, where evidence of the influence of the comorbidities on mortality exists. Hannan, Arani, Johnson, Kemp and Lukacik (1992) found clinical indicators of CAD, such as hemodynamic instability, shock and ejection fraction which are available only in primary data, to be predictive of in-hospital mortality after PTCA. But the authors did find significant differences in in-hospital mortality rates in PTCA patients with the following characteristics: (a) previous AMI within 7 days (3.0%), (b) stroke (4.65%), (c) carotid/cerebrovascular disease (3.1%), (d) aortoiliac disease (4.9%), (e) femoral/popliteal disease (2.9%), (f) persistent ventricular arrhythmia (4.6%), (g) congestive heart failure (7.4%) and (h) renal failure (5%). Looking at CABS mortality, dialysis dependency (Odds Ratio = 3.2) was predictive of in-hospital death (Hannan et al. 1990).

The third issue when adjusting for comorbidities is the type of measure selected: generic, site-specific or condition-specific measures are available. The MedisGrps measure (Brewster et al. 1985) is an example of a generic severity index, while the Acute Physiology and Chronic Health Evaluation (Kraus, Zimerman, Wagner, Draper, & Lawrence, 1981) is a setting-specific measure designed to be used in intensive care units. The Parsonnet (Parsonnet, Dean & Bernstein, 1989) and Higgins systems (Higgins, Estafanous, Loop, Beck, Blum & Paranandi, 1992) are condition-specific, clinical severity scoring measures developed to predict operative mortality and morbidity in CABS patients. All of these indices are obtained only from retrospective, chart review and are unavailable in administrative databases.

The generic Charlson index can be calculated from diagnoses contained in administrative databases (Charlson, Pompei, Ales and MacKenzie, 1987). The need to stratify patients in RCTs based on comorbidities in order to avoid confounding of the primary endpoint and to enhance generalizability was the impetus for its development. An empirically weighted index was developed to predict mortality based on the presence or absence of twenty specific comorbid conditions, as well as their severity. The index was validated against a consensually developed index (Kaplan & Feinstein, 1974) on a sample of breast cancer patients followed for ten years. Age was also found to be important as a predictor of mortality and an age-adjusted index was explored. The authors cautioned that further study was required on larger and more diverse populations. The index was originally based on medical record review and gained widespread acceptance.

Applying the index to the Manitoba database to examine readmission and mortality projections, predictions were not improved with the addition of primary data (Roos, Sharp, Cohen & Wajda, 1989). Deyo, Cherkin and Ciol (1992) adapted the Charlson index for abstracting ICD-9-CM hospital discharge administrative data. D'Hoore, Sicotte and Tilquin (1993) found that the index predicted short term mortality as well as, or better than, several risk adjustment models but acknowledged that regression coefficients would be low in conditions with low death rates. An alternative method to Deyo's for mapping the Charlson index to ICD-9-CM codes identified similar prevalence of comorbid conditions, but found significant differences in the comorbidity weights (Romano, Roos & Jollis, 1993). Two reasons that the Charlson index is less generalizable for use in this CAD procedural study are: (a) the low operative mortality rates associated with CABS and PTCA, and (b) the inclusion of diagnoses such as dementia and malignancies in which CABS and PTCA are unlikely to be performed.

Rather, a recent comorbidity methodology specifically developed for use in administrative databases in CABS populations was employed to classify comorbidities (Luft & Romano, 1993). The comorbidities had been selected to assess variations in hospital mortality rates for CABS patients in 115 hospitals in California from FY 1983/84 to 1989/90; 66,335 patients had comorbidities recorded. The study identified eight diagnoses, nine procedures, four sociodemographic variables and nine interactions. The logistic coefficients for in-hospital mortality were positive for: (a) age 60-64 years

(0.232), (b) age 65-69 years (0.446), (c) age 70-74 years (0.616), (d) age 75-79 years (0.859), (e) age 80 years and over (1.028), (f) coagulopathies (1.110), (g) CHF (1.150), h) hypertension (0.245), and (i) aneurysm (0.395). The logistic coefficients were negative for only one procedure, internal mammary artery (-0.335). These comorbid conditions from the index admission were also found to be predictive of adverse bypass outcomes in current and subsequent hospitalizations. No validation studies have been reported to date.

The Luft and Romano classification was developed on CABS patients only; this study extended its use to angiography and PTCA patients. Because angiography and PTCA patients were included in this study, two of the procedure codes used by Luft and Romano had to be deleted: (a) internal mammary artery bypass which had a negative coefficient and is unapplicable in angiography and PTCA, and (b) cardiac catheterization with or without CABS one or more days after, because this code was permitted by this study's inclusion criteria and was unapplicable in PTCA. On the other hand, an additional comorbidity, previous myocardial infarction had been identified as a clinical risk factor for operative mortality in major reviews (Leape et al. 1991), and so was added and tested in this study.

Separating comorbidities from complications is the fourth issue requiring attention when adjusting for comorbidities in administrative data. Abstracting diagnostic codes from prior hospitalizations can distinguish pre-existing comorbidities from procedural complications and also increases the number of comorbidities recorded in administrative data (Romano et al. 1994). Recognition of the need for comorbidity adjustment in administrative databases occurred in Canada in 1987, with the expansion of Hospital Medical Records Institute when a new variable, DXTYPE, became mandatory on discharge abstracts. This variable distinguishes between complications and comorbidities for up to 16 diagnostic codes. In contrast, the Luft and Romano methodology used 14 comorbidities; eight were diagnostic codes, but six were procedure codes. Since the DXTYPE variable allocates comorbidities only to diagnoses and not to procedure codes, the Luft and Romano cardiovascular-specific index has the potential to yield more sensitive results. An additional reason for not utilizing the DXTYPE variable was that while its coding was required on Manitoba abstracts in 1987, it was not until 1990, the last two years of this study, that the variable was associated with diagnoses in greater than 99% of cases (Roos, Stranc, James & Walld, 1995). Future research involving a sensitivity analysis to compare the results of the elimination and inclusion of the Luft and Romano procedure codes, would address the current requirement for their inclusion. Then validation of the Luft and Romano diagnostic comorbidities using the DXTYPE codes would be required to determine whether the Luft and Romano methodology distinguishes comorbidities from complications.

In summary, four issues require attention when adjusting for comorbidities in administrative databases: (a) lower prevalence of chronic conditions occur than when using primary, clinical data and can lead to bias in risk estimates, (b) coronary artery disease severity has been found to be predictive of mortality but is unavailable in administrative data, (c) condition-specific comorbidities are thought to yield more precise estimates and one measure is available for use in administrative databases, and (d) comorbidities may also include complications and diagnostic codes from previous hospitalizations may distinguish between these. This study will describe the number and percentage of comorbidities present at the time of angiography, CABS and PTCA using a modified Luft and Romano methodology. Comorbidities present in at least 2% of CABS and PTCA cases will be entered into the survival analyses in order to assess the impact of comorbidities on CABS and PTCA survival.

Waiting Time. Waiting time or queuing for cardiovascular procedures is a major policy issue in countries with national health insurance such as Canada (Morris, Roos, Brazaukas & Bedard, 1990) and the U.K. (Naylor, 1991). During the Clinton health reform initiative, waiting time for cardiac surgery became one of the focal points in the policy debate about the merits of national health insurance. Opponents of the plan cited prolonged waiting times accompanied by 'preventable' deaths in countries with national health insurance as one reason to reject the plan. Proponents however, acknowledge that rationing occurs in all countries, but claim that queue-based rationing is a fairer system than price- or income-based rationing. Waiting time for surgical procedures is longer in Canada than in the U.S. and this is purported to be a function of hospital bed capacity, human resource availability, equipment availability, funding mechanisms or all of the above.

In Canada, priorities on waiting lists for CVD procedures initially were constructed from subjective criteria. Morris and colleagues (1990) applied consensus criteria developed by the Rand Corporation to a cardiac catheterization waiting list of elective patients in a Manitoba tertiary care hospital. Patients on the waiting list and those treated on an Immediate Care basis were compared over an 18 month period through a retrospective chart audit. The two groups were similar in age and CAD but differed significantly on clinical indicators. Elective patients had a mean waiting time of 4.2 weeks and those with more severe CAD waited the shortest period; patients with other heart conditions waited longer. The morbidity and mortality experiences of both groups were described but could not be compared because of the absence of a waiting period in the Immediate Care group.

Naylor, Basinski, Baigrie, Goldman and Lomas (1990) used a cardiovascular practitioner consensus panel to design an urgency rating scale; later, a scoring system for the urgency scale to prioritize waiting lists was constructed from informed opinion and evidence from a literature review of RCTs (Naylor et al. 1991). The urgency rating scale ranged from 1 = emergency same day surgery, to 7 = marked delay of 3 - 6 months. A chart audit at four Ontario hospitals found that mean waiting time varied significantly among hospitals even when controlling for urgency scores. A positive correlation $r = 0.42$ ($P < 0.0001$) between urgency ratings and waiting time for CABS was found, however over half the patients waited longer than the recommended time for their rating. The effects of waiting time on outcomes were not investigated (Naylor, Levington, Wheeler & Hunter, 1993). Naylor, Levinton and Baigrie (1992) found that

"...extant research on queue-related issues has highlighted the psychosocial and economic impact of waiting periods for CABS. Mortal risk while awaiting CABS has not been analyzed, apart from a retrospective case-control study ... at a single hospital in the Netherlands" (p.720). In order to defuse controversy surrounding subjectively-based waiting lists, such as reports of queue jumping and deaths while waiting for surgery, a computerized, objective provincial database to monitor waiting time and channel referral to centres with shorter queues has been implemented in Ontario in 1992. No such provincial database exists in Manitoba.

The definition of waiting time is not consistent across studies. It may be that the variable, admission status, used in some studies is a proxy for waiting time or perhaps, severity of CAD. Some investigators define waiting time as the time from which the decision to refer for the therapeutic procedure is made until the time when the procedure is performed. The decision to refer is captured from the data when the patient is entered on the waiting list or booked for the procedure. In contrast lacking a centralized, computerized waiting list, this study quantifies waiting time from the date of angiography to the date of the therapeutic procedure, CABS or PTCA. It is recognized that this definition is not entirely related to queuing and that after the angiography, the physician may discuss treatment options, recommendations and risks with the patient; the patient may require time to reach a decision. Patients may also elect to try or remain on medical therapy. This decision-making time is incorporated into this study's definition and thus the time interval may be an overestimation compared to other studies which measure time from the decision to refer. Since CAD severity is not available in the database and Manitoba does not have a computerized waiting list, this study cannot determine whether patients' clinical status changed and their original proposed wait changed in response.

This study will describe the sociodemographic characteristics of Manitoba patients who wait different time intervals. Although waiting time is assumed to affect mortality, to date only a study at one hospital in the Netherlands has examined the impact of waiting time on CABS mortality (Suttorp, Kingma, Koomen, Tijssen, Defauw & Ernst, 1989). This observational study will analyze the impact of waiting time on CABS and PTCA survival, while controlling for other covariates. It is doubtful whether an RCT to study the effects of waiting time would obtain ethical approval and/or sufficient enrolment. In contrast, this longitudinal design is the particularly suitable to initially address the question "Does waiting time effect CABS and PTCA survival?"

Summary

This study examined secular trends in the utilization and outcomes of CAD procedures in Manitoba over six years using a longitudinal, observational design. A description of the methods, methodological issues and analytical techniques is presented in chapter 2. In chapters 3, 4, and 5, the hypotheses tested are formulated and the baseline demographic and clinical characteristics associated with angiography, PTCA and CABS are described. Chapter 5 includes the results of the survival analyses. Chapter 6 presents the regional utilization and mortality rates associated with the procedures. Unadjusted provincial and regional rates were adjusted for age, gender and income quintiles in order correct for any differences in the underlying distribution of these variables in the Manitoba population. Finally, chapter 7 concludes with an interpretation of the results and their contribution to the literature.

CHAPTER 2

Methods

Introduction

This study examined the utilization of, and outcomes associated with, angiography, CABS and PTCA in Manitoba from FY 1987/88 to 1992/93. The specific hypotheses tested are articulated in the relevant chapters. In this chapter the methodology used in the study is described. Advantages and disadvantages of the design and data sources are reported. Rationale for selection of ICD-9-CM procedure codes for angiography, CABS and PTCA are presented and the selected codes are compared to those used in other major coronary artery (CA) procedure utilization studies. The linkage of separate files in the MCHPE database to construct the longitudinal files is described and examples provided about the construction of derived variables. While the selection of the Luft and Romano (1993) comorbidity methodology was described in Chapter 1, modifications to it are reported and baseline comorbidities are compared to those found in other studies. Lastly, technical issues concerning decisions about counting events in longitudinal files are addressed and the sample is described.

Study Design

This study of utilization of coronary artery procedures employed a longitudinal, observational design and used MCHPE administrative data. The design used an inception cohort assembled at the time of angiography and included patients who: (a) were Manitoba residents, (b) were 25 years of age and over, and (c) had angiography performed in Manitoba hospitals between FY 1987/88 and 1992/93. Eligible patients were followed for up to six years to determine: (a) if they had CABS or PTCA, and (b) their survival after these procedures. Patients who had heart valve or septum repairs (ICD-9-CM codes 350-3599) during the revascularization admission were excluded because it would not be possible to separate the effects of these procedures from those of PTCA or CABS.

A longitudinal, observational design: (a) is relatively inexpensive to conduct and can quickly yield information about statistical associations at lower costs relative to case control studies or RCTs, (b) is well suited to the study of chronic diseases where there are long latency periods, (c) accumulates large numbers of patients required to detect differences in outcomes, and (d) permits assessing effectiveness of procedure/s on a more representative sample of the general population. Since RCTs are usually efficacy studies conducted in academic settings, the results are often not generalizable to other institutions with different patient populations and medical expertise. Thus observational studies can provide information that is complementary to RCTs.

Disadvantages of the design are that: (a) unlike an RCT design, it cannot determine causality as patients cannot be stratified on predefined variables to ensure comparability and then randomly assigned to treatments to determine efficacy of treatments, (b) changes in diagnostic criteria and treatment methods may occur over the long study period making results less relevant, and (c) unlike a case control design, incidence rates and relative risks cannot be calculated because a control group is missing.

This longitudinal observational study used secondary data, the MCHPE administrative database, and the limitations and advantages of administrative databases are reviewed.

Disadvantages of administrative databases

In comparison to clinical databases, the foremost disadvantage of administrative databases is the absence of clinical information which could enable more accurate prediction of outcomes. Because administrative data are collected for reimbursement purposes, they were not designed to record clinical data. Many clinical variables pertinent to a study of the outcomes of PTCA or CABS are not reported on discharge abstracts and cannot be analyzed using administrative databases. These include: (a) severity of unstable angina, (b) results of exercise testing, (c) results of angiography such as the number and percentage of stenosis of vessels, (d) left ventricular ejection fraction, and (e) urgency of surgery (Hlatky, Califf, Harrell, Lee, Mark, & Pryor, 1988; Hannan, Kilburn, O'Donnell, Lukacik & Shields, 1990; Tu, Jaglal, Naylor, 1995). Additionally, clinical data relevant to CVD risk factors which may also predict complications, survival or disease progression leading to recurrence, such as smoking status, obesity, hyperlipidemia, social supports and job satisfaction are not available in claims data.

A second disadvantage of administrative databases is the reliance on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes since they are prone to the inaccuracies and imprecisions contained in the classification system (Iezzoni, Burnside, Sickles, Moskowitz, Sawitz & Levine, 1988). When claims data are used to code comorbidities, comorbidities are severely underestimated. Claims data from July 1985 to May 1990 were compared with clinical data on the same 12,937 angiography patients at Duke University Medical Center. Twelve prognostic indicators were assessed and over half of the patients with the conditions were missed by the claims data (Jollis, Ancukiewicz, DeLong, Pryor, Muhlbaier & Mark, 1993). The authors note that diagnostic accuracy in claims data in the U.S. improved by 13% between 1985 and 1990. Additional imprecisions in administrative data occur when distinguishing between comorbidities and complications. In the U.S., a methodology to identify complications on adult medical and surgical hospitalizations from the discharge abstract is promising but requires further evaluation (Iezzoni et al. 1994). In Canada work on separating complications from comorbidities in the diagnostic coding began too late to be used this study.

A third disadvantage of administrative databases is that they are prone to the measurement bias known as diagnostic purity bias which occurs "...when 'pure' diagnostic groups exclude comorbidity they become non-representative" (Sackett, 1979, p.61). Administrative databases require case mix adjustment to control for possible differences in patient characteristics if treatments are to be compared. Differences in severity of illness, as measured by primary data obtained from chart abstraction using indices such as Staging, Medisgroups etc. are often predictive of differences in outcomes but are not available in administrative databases. Iezzoni (1992) identified twenty variables as dimensions of risk adjustment, however only three are contained in the MCHPE database: (a) age, (b) diagnoses, and (c) procedures. In spite of these limitations, studies have found high correlations between clinical and administrative database in predicting in-hospital mortality. The correlation between the Medisgroups risk adjustment system and claims data in predicting mortality was 0.91 and the addition of the clinical data resulted in an improvement of only 0.04 (Krakauer et al. 1992). In comparing clinical and administrative data to examine in-hospital risk adjusted CABS mortality rates, slightly lower (0.75) correlations were reported (Hannan, Kilburn, Lindsey & Lewis, 1992).

The final disadvantage of administrative databases concerns mortality. Typically administrative data contain information only on in-hospital mortality and thus long term survival analyses cannot be calculated. In Canada, mortality information about all deaths wherever they occur, is available but it cannot be linked directly to administrative data because Statistics Canada does not provide unique identifiers with its mortality data. To overcome this problem, probabilistic record linkage methods were employed to merge the federal mortality data with MCHPE data and this results in approximately a 2% error rate. Up to two causes of death are recorded on the mortality database and these diagnoses are themselves subject to error (Guibert, Wigle, & Williams, 1989). The ability to link federal data and the fact that insurance coverage is recorded in the MCHPE registry ensures that survival analyses can be conducted in this database unlike most administrative databases.

Advantages of administrative databases

Advantages of administrative databases are that: (a) they are comparatively inexpensive to use as they are usually a secondary data source already collected for reimbursement purposes, (b) they are collected non-intrusively and are collected in a manner unconnected to the hypothesis of interest, (c) because individual identifiers are used, individual longitudinal histories can be constructed, and (d) selection biases such as non-respondent, volunteer and recall biases are minimized because data on the entire population are collected.

Administrative databases of the highest quality have three distinguishing characteristics: (a) coverage of the entire population by their place of residence, (b) individual, unique identifiers allow tracking of utilization over time and across settings, and (c) a registry which records when coverage begins and ends (Roos & Roos, 1989). This population-based, longitudinal study used MCHPE administrative data which meet these stringent criteria. The existence of an enrolment registry file enables tracking of loss to follow-up which is required for survival analyses. Because the registry file identifies when health insurance coverage begins and ends, incidence rates can be ascertained and "...denominators for research on the epidemiology for health care utilization..." can be determined (Roos & Nichol, 1983, p.967).

The reliability and validity of the data has been extensively established (Roos, Sharp, Cohen & Wajda, 1989). Prior to using unique identifiers, when family identifiers were used only 9% of men and 8% of women aged 40-59 were lost after eight years of follow-up. Compared to primary data collection such as the Keys Seven County Study in which the response rate for men aged 40-59 years after 10 years of followup ranged from 0.81 to 0.93, the response rate in a Manitoba sample followed for 8.5 years was 0.91 (Roos, Nicol & Cageorge, 1987). Verification of surgical procedure codes from the physician claims files and the hospital file resulted in high agreement; consultations and treatments were less reliable (Roos, Roos, Cageorge & Nicol, 1982). The MCHPE registry population was 2% higher than the 1971 census, however out-of-hospital deaths were under-reported (Roos & Nicol, 1983). A 1989 study established the validity of a frequently performed diagnostic test (Cohen & Hammarstrand) while a 1991 study examined the validity of the diagnostic code, diabetes mellitus (Young, Roos & Hammerstrand). In summarizing the advantages of the MCHPE database for longitudinal studies, Roos, Nicol and Cageorge (1987) point out that the research is unobtrusive and the entire population is available so that sampling is unnecessary and selection bias is avoided.

Ethical Review

The proposal received approval from the University of Manitoba Faculty of Medicine's Review of the Use of Human Subjects and Manitoba Health's Access and Confidentiality Committee. It should be noted that no individual patient, physician or hospital is identifiable in the report.

Selection of Procedure Codes

Selecting accurate ICD-9-CM procedure codes and ensuring that codes were compatible with other investigators in order to enhance the possibility of collaborative comparative studies was the first task. Codes used by other investigators (Roos & Sharp, 1989; Muhlbaier, 1992; Anderson, Grumbach, Luft, Roos, Mustard & Brook, 1993; Jaglal, Goel & Naylor, 1994; Topol et al. 1993; Luft & Romano, 1993) were compared (Table 1) and found to be similar.

Table 1

Variability of ICD-9-CM Procedures Codes for Angiography,PTCA and CABS Utilized in Prior Studies

Investigators	Angiography	PTCA	CABS
Anderson et al. 1993			361, 3610-3616, 3619
Jaglal, Goel & Naylor, 1994	3721-3723 8855-8857	3600-3602 3605	3610-3616 3619
Luft & Romano, 1993			361-369
Muhlbaier, 1992	3721-3723 8850-8858	3600, 3601-3603, 3605, 3609	361-3616, 3619
Roos & Sharp, 1989	8850-8858		3611-3614
Topol et al. 1993	3722-3723 8853-8857	360, 3601-3602, 3605, 3609	361-3616 3619
Hartford, 1996	3722-3723 8853-8857	3601-3602 3605	361-3616 3619

The following codes were included by other investigators but excluded from this study: (a) '8850' - angiography, not otherwise specified (NOS), (b) '8851' - angiography of venae cavae, (c) '8852'- angiography of right heart structures, (d) '3603' endarterectomy, and (e) '3609'- other removal of coronary artery obstruction excluding PTCA. Consulting with a St. Boniface General Hospital cardiologist facilitated decisions about codes to retain. For example, '8852', "Angiography of the right heart structure" is used to diagnose atrial, ventricular or valvular disease, and while '8852' is an angiography code, it is not appropriate for the diagnosis of coronary artery disease. Similarly, '3721', "Right heart cardiac catheterization" was excluded for the same reason. On the other hand, code '3723', "Combined right and left heart catheterization" does enable diagnosis of both coronary artery disease and valve disease and therefore was retained. For FY 1991/92, a frequency count of the codes used by other investigators but excluded in this study identified: (a) '8850' (angiography NOS) = 3, (b) '8851' (angiography of venae cavae) = 19, (c) '8852' (angiography of right heart) = 7, (d) '3603' (endarterectomy) = 12, (e) '3609' (other removal of coronary artery obstruction excluding PTCA) = 3, and (f) '3721' (right heart cardiac catheterization) = 55. As displayed in Table 1, the final codes used in the study were: (a) Angiography = '3722', '3723', '8853'-'8857', (b) Percutaneous Transluminal Coronary Angioplasty = '3601'-'3602','3605', and (c) Coronary Artery Bypass Surgery = '361_'- '3616', '3619'.

Construction of longitudinal files

Four MCHPE files were used in this project: (a) Manitoba Health's hospital discharge abstract file which contained both inpatient and outpatient data, (b) the MCHPE registry file which identified the status of insurance coverage, (c) the 1986 Statistics Canada census file which contained data on the Manitoba population and income, and (d) Manitoba Health's physician claims file which contained billing information. Individualized Ischemic heart disease (IHD) longitudinal histories were constructed by MCHPE for FY 1987/88-1992/93. Based on a preliminary frequency distribution of the relevant ICD-9-CM procedure codes from the hospital file, the histories contained hospital admissions from: (a) the index angiography and up to three subsequent readmissions for angiography, (b) up to two CABS admissions, and (c) up to four PTCA admissions. Thus each patient record could potentially contain ten hospitalizations. All files from FY 1987/88 to 1992/93 with index angiography were selected and were followed for PTCA and CABS; these files were linked and summarized on a single record. A unique personal identifier allowed record linkage between the registry and the hospital file and physician claims file. However, for linkage to the census file, an individual was linked by their postal code to an enumeration area because census data was not available at the individual level.

From the registry file, sociodemographic variables consisted of: (a) date of birth, (b) earliest known coverage date, (c) last known coverage date, (d) reason for loss to follow-up, (e) date of death, and (f) marital status. The variables concerning death and loss to coverage were important in conducting the survival analysis as they provided information about censoring. Individuals were linked through their Manitoba Health registry postal code to the 1986 Statistics Canada census EA income file. From census file, four variables on household income at the enumeration level were available: (a) income decile ranking for all Manitoba, (b) rural income decile ranking for rural Manitoba, (c) urban income decile ranking for urban Manitoba, and (d) mean income mean household income at the E.A. level. The 1986 census file population was also used for age and sex standardization in calculating rates.

From the hospital files for FY 1987/88-1992/93, the following are examples of key variables that were retained: (a) PHIN91 (a unique identifier), (b) age (date of birth), (c) sex, (c) date of admission, (d) discharge date, (e) admission status, (f) autopsy, (g) six diagnosis related grouping variables, (h) diagnosis 1-16, (i) diagnosis type 1-16, (j) three hospital identifier variables, (k) length of stay, (l) municipal code, (m) municipal size, (n) number of days preoperative, (o) operative procedures 1-12, (p) postal code, (q) province of residence, (r) readmission, (s) registration number, (t) region of residence, (u) separation code, (v) service location code, (w) surgery date 1-12, (x) transaction code, (y) two transfer variables, and (z) admission and transferring hospital. ICD-9-CM diagnostic and procedure codes from the hospital file were used to identify comorbidities for the Luft & Romano (1993) methodology. This methodology identified eighteen comorbid conditions from index CABS admission that had been found to be predictive of adverse outcomes in current and subsequent hospitalizations; these comorbidities are listed in Table 2.

From the physician files for FY 1987/88-1992/93, the following variables were used: (a) patient identifier, (b) patient gender, (c) patient date of birth, (d) patient first initial, (e) physician identifier, (f) procedure tariff codes, (g) hospital identifier, and (h) date of service. The physician claims file was linked to the hospital file to eliminate duplicate counts of procedures performed on patients transferred from community hospitals to the teaching hospitals for the procedures. In summary, the ischemic heart disease (IHD) longitudinal history file was composed of an inclusion screen, in this case index angiography, and up to nine subsequent hospitalizations. The subsequent hospitalizations included up to: (a) three additional angiographies, (b) four PTCA, and (c) two CABS.

Construction of Derived Variables

In addition to the variables contained on the hospital and registry files, it was necessary to construct new variables. Examples of variables constructed specifically for this study are discussed.

Age. Age was constructed by subtracting the date of admission from the date of birth. Although age is a continuous variable, in the descriptive analyses six age group intervals were constructed: a) 25-34, b) 35-44, c) 45-54, d) 55-64, e) 65-74, and f) 75 and over. In the model building conducted in the survival analyses, three different age group intervals were entered into the model: a) base 25-64 and 65+, b) base 25-64, 65-74 and 75+, and c) base 25-64, 65-69, 70-74, 75-79 and 80 and over.

Region of Residence. The province of Manitoba is divided into administrative health regions. At the beginning of this study the province was divided into seven health regions: (a) Central, (b) Eastman, (c) Interlake, (d) Norman, (e) Parkland, (f) Westman and, (g) Winnipeg. In FY 1989/90, the Winnipeg Region was further subdivided into three regions and the total number of regions was nine. Municipal codes are allocated to local government districts, rural municipalities, villages, towns and cities and these codes are aggregated into regions. Because this study bridged the time period across 7 to 9 regions, it was necessary to use seven regions for any comparative analyses. This was complicated by the fact that some municipal codes had not existed prior to FY 1989, while some unorganized territories had not been allocated municipal codes prior to 1989. A frequency distribution of municipal codes by 7 and 9 regions identified those municipal codes and unorganized territories with no allocation. Manitoba Health was contacted to classify the unallocated codes. A computer program was subsequently written to allocate the municipal codes to the regions.

Because coronary artery procedures are centralized in two teaching hospitals in Winnipeg, regional analyses are based on the region of residence of the patient, regardless of where the service was provided. Thus patients from Interlake who received their angiography in Winnipeg were counted as an Interlake resident. Preliminary analysis identified that using seven regions often resulted in too few observations and so the seven regions were collapsed into three: (a) the Western Region consisting of Westman and Parkland, (b) the Winnipeg Region, and (c) Other Rural Regions consisting of Central, Eastman, Interlake and Norman. It was important to retain the Western Region as a separate region because a previous study (Roos & Sharp, 1989) had noted lower angiography and CABS utilization rates in that region and it was vital to determine if the trend continued.

Socioeconomic Status. Household income was obtained from the 1986 Canadian census and was used as a measure of socioeconomic status (SES). The sampling unit in the census is a household; 100% of the population completes the short (2A) form of the census and a random sample of 20% of households complete the long (2B) census questionnaire on which income data is required. Household income is defined as the sum of income earned in calendar year 1985 reported by all members of the household over the age of fifteen from the following sources: (a) wages and salaries, (b) net non-farm self employment income, (c) net farm self-employment income, (d) family allowances, (e) federal child tax credits, (f) old age security pensions, (g) benefits from the Canada Pension Plan, (h) unemployment insurance payments, (i) dividends on interest, retirement pensions, and (j) other income sources (Statistics Canada, 1987). Mustard (1991) has identified a number of systematic and random measurement errors in the 1986 census data: (a) in order to protect confidentiality of single households, Statistics Canada uses the random rounding procedure to convert values of specific cells by a multiple of 5, (b) cell suppression is also used to convert small cells with small numbers of observations to zero, (c) additionally, a number of status indian reservations boycotted the 1986 census and an estimated 8000 aboriginals were not enumerated, and (d) for household incomes, which are obtained from all household residents fifteen years of age and over who complete the 2B form, average incomes are calculated from unrounded data by dividing the aggregate household income in the EA by the number of households.

Enumeration areas (EA) are the smallest level of aggregation of census data and each EA represents from approximately 125 (in rural areas) to 375 (in urban areas) households. In the 1986 census there were 1,825 EAs in Manitoba with resident households. Statistics Canada defines an urban EA as one which has a population density of 400 people per square kilometre. This definition does not correlate with common usage of the terms rural and urban, nor does it fit the definition of the three health regions and thus the census variables (a) rural income decile ranking for rural Manitoba, and (b) urban income decile ranking for urban Manitoba could not be used in this study. Because there is no postal code reporting on census data, Statistics Canada has developed a postal code conversion file which matches EA to postal code. Since EAs and postal codes do not map in a one-to-one fashion, a technical users manual is provided by Statistics Canada. The program also assigns links when postal codes cross multiple EA boundaries; this occurs in 95% of the rural postal codes. MCHPE developed formats for linking census data to Manitoba Health registry data (Mustard, 1991).

Data for the EA are aggregated to the level of municipality. In Manitoba, the mean household income for an urban EA was \$32,506 (SD $\pm$ \$13,237) and for a rural EA, \$26,072 (SD $\pm$ \$8,997). On a regional basis, using eight health regions (Thompson in 1986 was a separate region which was subsequently amalgamated with Norman), Frohlich and Mustard (1994) noted that average household income ranged from a high of $33,402 in Winnipeg to a low of $22,616 in Parklands. In their construction of a socioeconomic risk index to explain differences in the health status of Manitobans, household income was not found to enhance the predictive power of other measures in the index. Whether income was collinear with other socioeconomic indicators was not identified. Another interpretation for the inability of income to increase the predictive power of the index may be the homogeneity of mean incomes aggregated at the regional level. This is plausible when one considers that over half of the population resides in Winnipeg. Frohlich and Mustard's findings do not mean that one cannot distinguish different utilization patterns based on census income data, but that the data did not enhance the predictive power of health status utilization in the face of other SES measures.

In this study, individuals in the longitudinal file were linked through their Manitoba Health registry postal code to the census EA income file. After aggregation to the regional level, the seven regions were collapsed into three as discussed earlier. This study examined:(a) the distribution of angiography, CABS and PTCA by income quintile, (b) the relationship between income quintiles and other sociodemographic and clinical characteristics, (c) the relationship between income and utilization rates, and (d) whether income predicted survival.

Modification of Comorbidities

The MCHPE database contains up to 16 diagnostic codes and up to 12 procedures codes for each admission. To describe and assess the impact of comorbidities, the Luft and Romano (1993) comorbidity classification was selected. While developed for CABS this study adapted the comorbidity scheme and extended it to angiography and PTCA. Adaptation consisted of deleting two nonapplicable procedures and including one more diagnosis. The inclusion of angiography and PTCA resulted in the deletion of two of the procedure codes used by Luft and Romano: (a) internal mammary artery bypass is unapplicable in angiography and PTCA and which had a negative coefficient and, and (b) cardiac catheterization with or without CABS one or more days after, because it was permitted by this study's inclusion criteria and was unapplicable in PTCA. Thus, sixteen comorbid conditions were selected, eight diagnostic codes and six surgical procedures as displayed in Table 2.

Table 2

Selected Luft and Romano Diagnostic and Procedural Comorbidity Codes

Comorbidity - Diagnosis	ICD-9-CM codes
Diabetes	25001-2509
Coagulopathies	2869-2873, 2875-2879
Neurological Disorders	330-3419, 345, 358-3599
Heart Failure	39891, 40201, 40211, 40291,428
Hypertension	402-40599
Peripheral Atherosclerosis	440-4429
Liver Disease	571-5719, 5722-5728
Renal Disease	585
Comorbidity - Procedure	
Prior Implant Cardiac Device	3761-3762
Endarterectomy	3603
Major Vascular Procedure	381, 383-384, 390-391, 392.1-392.6, 392.9, 395
Major Abdominal Procedure	450, 453-481, 483-489, 500-529, 541
Other Major Procedure	320-329, 602-606, 810-818, 840-841, 843, 849.1
Ventricular Aneurysm	3732

Additionally a new diagnostic comorbidity, previous myocardial infarction (ICD-9-CM 412.00), was tested because of the frequency of its occurrence in other studies; previous myocardial infarction had not been included in the Luft and Romano comorbidities. Comorbidities were coded as dichotomous variables. The presence or absence of the comorbidities for each admission as recorded on the discharge abstract, was used in the descriptive analysis and to calculate adjusted relative risks in the survival analysis. The frequency distribution of medical comorbidities recorded on the admission for angiography, CABS and PTCA is displayed in Table 3 and the frequency distribution of surgical comorbidities is displayed in Table 4.

Table 3

Frequency of Medical Comorbidities Recorded on Index Admission for Angiography, PTCA or CABS (FY 1987/88-1992/93)

	Angiography (N = 10,520)	CABS (n = 2,699)	PTCA (n = 2,130)
Diabetes	211 (2.1%)	65 (2.4%)	27 (1.3%)
Coagulopathies	47 (0.5%)	101 (3.7%)	4 (0.2%)
Neurological Disorders	47 (0.5%)	18 (0.7%)	3 (0.1%)
Heart Failure	981 (9.3%)	391 (14.5%)	120 (5.6%)
Hypertension	82 (0.8%)	39 (1.4%)	15 (0.7%)
Periperhal Athero-sclerosis	159 (1.6%)	77 (2.9%)	8 (0.4%)
Liver Disease	16 (0.2%)	7 (0.3%)	1 (0.05%)
Renal Disease	114 (1.1%)	17 (0.6%)	14 (0.7%)
Previous Myocardial Infarction	638 (6.1%)	590 (21.9%)	213 (10%)

Table 4

Frequency of Surgical Comorbidities Recorded on Index Admission for Angiography, PTCA or CABS (FY 1987/88-1992/93)

	Angiography (N = 10,520)	CABS (n = 2,699)	PTCA (n =2,130)
Prior Implant Cardiac Device	1 (0.0%)	19 (0.7%)	1 (0.0%)
Endarterectomy	1 (0.0%)	NA	NA
Major Vascular Procedure	80 (0.8%)	19 (0.7%)	9 (0.4%)
Major Abdominal Procedure	49 (0.5%)	23 (0.9%)	4 (0.2%)
Other Major Procedure	36 (0.4%)	49 (1.8%)	1 (0.0%)
Ventricular Aneurysm	3 (0.0%)	39 (1.4%)	0 (0%)

Note. NA = Not Applicable.

An indirect comparison can be made between the logistic coefficients in the Luft and Romano study and the Cox proportions hazards risk ratios in this study. Six diagnoses and seven procedures were predictive of in-hospital mortality in 132,740 patients in 115 hospitals in the Luft and Romano study. Only six of the comorbidities occurred in more than 2% of the cases in the Manitoba study and of these, two diagnoses were predictive of decreased probability of survival over a six year period of time. The fact that two of the diagnoses from the Luft and Romano study were also predictive in this study which examined both CABS and PTCA patients, reinforces the utility of the method. The fact that so few cases of comorbidities were recorded in Manitoba likely accounts for the fact that only two comorbidities were predictive. Investigation continues into the reliability and validity of using hospital discharge diagnoses to assess comorbidity and it is ackowledged that comorbidity is underestimated when this type of methodology is used because of the dependence of recording on the abstract. Overall this study found that bypass patients had more existing comorbid medical conditions and surgical procedures than PTCA patients. Whether these comorbidities influence mortality will be examined in the survival analyses. Only those comorbidities with a frequency of 2% or more were retained in the survival analysis.

Other major studies have collected primary data to examine baseline comorbid characteristics of CABS and PTCA patients and these are displayed in Table 5.

Table 5

Baseline Comorbidities Found in Other Major CABS and PTCA Utilization Studies

	Hlatky[c]	Vet Admin	CASS	ECSS	Naylor[d]	Hannan[e]	Hannan[f]
Old AMI	55.3%	61.3%	59.9%	46%	28.8%	35.7%[a]	11.9%[b]
CHF	3.3%	6.9%				4.4%	5.3%
Diabetes	11%			6%		16.8%	
Hypertension							44.2%
COPD							6.6%
Stroke							1.5%
Cerebrovascular							2.7%
Aortoiliac							2.8%
Femoral/Popliteal							4.2%
Arrhythmia							1.9%
Renal Failure							1.7%

Note. [a] = greater than 7 days. [b] = within 7 days. [c] Hlatky et al. 1988. [d] Naylor & Levinton, 1993. [e] Hannan et al. 1990. [f] Hannan et al. 1992.

To emphasize that more sicker patients now have CABS, Jones and colleagues (1991) compared patients in 1981 with those in 1987: (a) AMI increased from 3.5%to 5.5%, and (b) diabetics increased from 15% to 24%. In a study of angiography and CABS in the early 1980's at one Manitoba hospital and three American hospitals, Roos and colleagues (1994) found that less than 1% of patients in each of the hospitals had CHF recorded at the time of angiography. While 4% of Manitoba angiography patients had a previous AMI recorded, in the American hospitals the percentage ranged from 2-3%. Previous AMI was recorded in less than 1% of Manitoba CABS patients and in 2-3% of the American CABS patients. In summary, (a) comorbidities are underreported when extracted from the discharge abstract as opposed to primary data collection and, (b) the Luft and Romano methodology using administrative data identified comparable coexisting disease and more surgical procedures than are identified in other studies.

Decisions About Counting Events

There are problems particular to the construction of longitudinal histories. One of the problems concerns duplication due to updating when Manitoba Health releases corrections to its hospital files in the subsequent year. Approximately 1% of records in the current year are corrections to the previous year. Only one or two fields may represent errors, however the correction process results in duplicate records; for the construction of the longitudinal file, the most current record was selected.

Accuracy of Variables Over Time

Another problem associated with the construction of longitudinal files involves accuracy of variables over time. An example of such a problem is the age of the patient. Because there were a maximum of 10 hospitalizations over the six years, there were also ten possible age variables and a decision on the definition of age was required. Age was defined as age at separation for the claim containing each procedure; thus for each procedure examined in the analysis, the age of the person was related to the specific procedure at that time. All hospital variables were retained on the file for each admission and these variables were distinguished from one another by a prefix, e.g. a1datead, a2datead, p1datead, c1datead, etc.

Angiography Associated with Angioplasty Procedure

A frequency distribution identified that in most cases, both the codes for angiography and PTCA are recorded when PTCA is performed. This occurred even in cases where a previous diagnostic angiography had been recorded. PTCA requires that radio-opaque dye be inserted via a catheter into the coronary artery in order to visualize the site of the coronary stenosis: this portion of the procedure is the angiography. Next the balloon catheter is inflated in order to dilate the atherosclerotic plaque: this portion of the procedure is the angioplasty. This distinctive manner of coding the PTCA procedure required a decision in order to prevent double counting of angiography and PTCA. The decision was made that when angiography and PTCA occurred on the same day and index angiography had occurred previously, only the PTCA was to be counted. The decision to delete angiography from PTCA when they both occurred on the same day and when a previous index angiography existed, proved problematic when waiting time between angiography and PTCA was calculated. It became apparent that on some occasions (n = 163) index angiography occurred on the same day as index PTCA, that is no prior angiography could be found. Since the IHD database had been programmed not to allow a count of 0 days between index angiography and index PTCA, an analysis of the time between diagnostic and therapeutic procedures would have inaccurately indicated that no index PTCA occurred on the same day as index angiography. Thus in order to calculate waiting time in those cases where the PTCA was performed on the same day as the index angiography, another separate program was written and a separate file used for waiting time analysis.

Transfers from Community Hospitals to Teaching Hospitals, Procedure Codes

A frequency distribution of procedures by hospital identified that, when patients were transferred to teaching hospitals for angiography, both the referring hospital and the teaching hospital coded the procedure. Hospitals also selected ICD-9-CM codes differently, that is, in different orders and by selecting different possible combinations of codes. Thus in order not to overcount single events, a decision was made to count and record the codes occurring within the same episode of care only at the teaching hospital.

However, in 1989, 1,636 angiographies (81.7%) were recorded at the teaching hospitals and for the same year, 269 angiographies (14.7%) were recorded only at the non-teaching hospitals. Examining the original MCHPE hospital file (e.g.HSP 8990) used to construct the longitudinal histories, it was evident that these patients had been transferred to a teaching hospital within their stay at the non-teaching hospital and that the procedure which was performed at the teaching hospital had only been recorded on the community hospital abstract. As a further complication, these transfer records at the teaching hospital were for day surgery (TRANSACT=3 or 5). However, for reasons related to the procedure, it became necessary for the patient to stay over night, (e.g. ICD-9-CM 'V66.0' -Convalescence following surgery) and the patient was admitted as an inpatient to the teaching hospital. Usually after an overnight stay the patient was transferred back to the non-teaching hospital. Table 6 displays that one episode of care could result in a maximum of seven records.

Table 6

All Possible Combinations of Transfers During One Episode of Care

#1	Admitted to non-teaching hospital with previous acute myocardial infarction (ICD-9-CM 414)
#2	Transferred to teaching hospital for out-patient angiography
#3	Admitted to teaching hospital overnight
#4	Transferred to non-teaching hospital
#5	Transferred to teaching hospital for out-patient PTCA
#6	Admitted to teaching hospital overnight
#7	Transferred to non-teaching hospital and eventually discharged

At the beginning of the study, it was noted that angiography and PTCA occurred on an outpatient basis and that transfers from non-teaching to teaching hospitals for these procedures also occurred in some instances. However, the frequency of transfers was not known. A decision had been made to select the more accurate procedure code from the teaching hospital record and other information from the non-teaching hospital record, so as not to lose the length of stay information related to the episode. This previous decision resulted in major data loss.

In order to try and salvage as much of this data as possible the procedures on the hospital file were linked with those on the physician claims' file. Claims are submitted to Manitoba Health for reimbursement. In Manitoba, most physicians practice on a fee-for-service basis and even salaried physicians submit claims for government record-keeping purposes. Procedure tariff codes on the physician claims file are not identical to the ICD-9-CM procedure codes on the hospital file and must be individually matched. The tariff codes for angiography were 2302- 2305, 2308, 2325 and 2327.

Using software called LinkPro (Roos & Wajda, 1991), a programmer conducted five distinct record linkage steps for those records with a single angiography and the same identifier on both the hospital and physician file. While 76% of records matched on the service date prior to the linkage, 97.6% matched by the completion of the linkage (Roos, Walld, Wajda, Bond & Hartford, 1996).

<u>Counting Comorbidities</u>

A frequency count of comorbidities often resulted in a larger denominator than the number of procedures. This occurred because when comorbidities were selected from the records of all admissions for CABS and PTCA, and not just for all patients who had only one procedure, this resulted in overcounting because some patients had multiple procedures. In order to rectify this, a decision was made to select comorbidities from the admission in which the procedure occurred; however, due to the multiple transfers, this resulted in data loss. Again the original hospital file was examined and it was noted that these patients had transfers to teaching hospitals within their stay at the non-teaching hospital; thus the stay at the teaching hospital fell within the longer stay. When the file was sorted in descending order by separation date, the longer stay would have appeared first and the diagnoses from that stay retained.

As illustrated in Table 6, the PTCA record would have been record #5, but because of recording inconsistencies, relevant diagnoses could have been on any record. In one case, a comorbid condition of interest, diabetes, was only on record #1. It became apparent that the original decision about what information to retain was resulting in data loss and inaccuracies when constructing comorbidities. In the case of patients who were transferred, in addition to the admission in which the procedure occurred, it seemed reasonable that comorbidities might have been more accurately recorded on the admission to the community hospital. Without a relational database, a reasonable solution to this problem was to add 16 diagnoses, 16 diagnoses types and 10 procedure codes from the first record to the longitudinal file resulting in a total of 32 diagnoses, 32 diagnostic codes and 22 procedure codes. This issue of counting comorbidities illustrates their underrecording on discharge abstracts.

Misclassification Information Bias

In longitudinal studies constructed using screening procedures, not all procedures performed are counted, but only those that meet the inclusion criteria. Knowing how many procedures are not enumerated by virtue of the choice of study design is important. In other words, what is the 'cost' of using index angiography as an eligibility screen; how many procedures were excluded because of index angiography had to be performed after April 1, 1987 in order to be admitted into the study? A sensitivity analysis was performed to assess the magnitude of this nondifferential misclassification information bias. Nondifferential misclassification information bias has been described by Rothman (1986) as obtaining information about a disease classification in a way that guarantees misclassification. When the misclassification of disease is independent of the classification of exposure to the disease, the misclassification bias is categorized as nondifferential and results in a bias towards the null.

Nondifferential misclassification information bias of disease would have occurred if index angiography had not been used as a screening procedure for entry into the study and all CABS and PTCA had been counted, rather than just the initial CABS or PTCA. Using angiography as a screen and counting only index CABS and index PTCA, on the other hand, leads to underascertainment of CABS and PTCA, which in turn leads to underestimation of the probability of CABS and PTCA outcomes. To quantify this bias, patients who had index angiography prior to April 1, 1987 were eliminated from the study and a sensitivity analysis was performed to account for the subsequent loss of CABS and PTCA subjects (Table 7).

Table 7

Sensitivity Analysis - The Effect of The Elimination of Index Angiography Prior to FY 1987/88 on Subsequent Types of Patients

Procedures	Angiography	PTCA	CABS
Include Index Angio from 04/01/87	8912	1807	2328
Exclude Index Angio from 04/01/87 to 04/01/88	8912	1611	2167
Difference	-0	-196	-161

Using index angiography performed after April 1, 1987 as a screen, there were 196 fewer PTCA patients and 161 fewer CABS patients than if index angiography in this period hadn't been the screen and the overall nondifferential misclassification rate would be 10.85% for PTCA patients and 6.9% for CABS patients. If the number of "misclassified" PTCA (196) and CABS (161) patients are examined on an annual basis, the "misclassification" rate that would have occurred is displayed in Table 8. Since it is counter-intuitive that the rate should increase over time, it is likely that the 1991/92-1992/93 CABS rates and the 1992/93 PTCA rate increases represented repeat procedures.

Table 8

Sensitivity Analysis - Annual Misclassification Rate (%)

	CABS	PTCA
1988/89	21.09	16.79
1989/90	4.87	11.85
1990/91	1.56	8.14
1991/92	3.40	6.51
1992/93	4.04	10.74

A second approach to sensitivity analysis is a sequential retrospective examination of the number of angiographies performed in each year which would have been classified as index, if data for the previous year had not been available (Table 9). Angiographies in the current year would have been classified as index when they were actually a second angiography. Such misclassification would lead to overestimation of angiographies. This may also lead to misclassification of PTCA and CABS as these procedures would not have been eligible for inclusion into the study without index angiography; however, the current database does not permit counting how many PTCA and CABS were excluded in this manner. The annual misclassification rate ranged from 7.18% to 9.49%.

Table 9

One Year Retrospective Count of Misclassified Index Angiographies

	Index Angiographies Misclassified	Total Index Angiographies	Percent Misclassified
1988	141	1,964	7.18
1989	140	1,893	7.40
1990	162	1,948	8.32
1991	200	2,107	9.49
1992	192	2,233	8.60

Waiting Time

In a society with queue-based rationing of resources, it would be expected that patients with less severe IHD and/or fewer or no comorbidities would have a longer waiting period between index angiography and index CABS or PTCA. A description of the length of time between index angiography and index CABS or PTCA for an entire province over a six year period of time was possible with the construction of longitudinal files. They also enable an examination of the relationship between this time interval and survival. While this time interval is referred to as waiting time, that is not strictly accurate since not all patients are on a formal or informal waiting list. For many patients, the time interval consists of: a) the physician's decision-to-treat time, (b) patients and families' decision-making time, (c) the time required to book the therapeutic procedure, and (d) the time after booking the procedure until the procedure is performed. There is some elasticity as this time interval may be elongated for elective patients and shortened for emergency patients. It should be stressed that the reasons for a short or lengthy waiting time cannot be completely understood or interpreted from administrative databases because other explanatory variables such as patient preferences, length of waiting lists, bed capacity, available human resources, and other clinical variables are not available in the database.

The definition of the concept, waiting time, has not been universally agreed upon. Some investigators seem to mean time from the decision to refer until the procedure is completed, while others define the concept as the time from when the patients is placed on a waiting list until the procedure is performed. Without an agreed upon definition of the concept, it is even more difficult to operationalize the concept and assigned descriptors to the waiting time intervals. Most often, patients who have their diagnostic and therapeutic procedures on the same day are regarded as emergency cases and waiting time would be a surrogate for severe CAD or comorbidities. But on some occasions, no waiting time may also be a surrogate for accessibility, that is, the patient had angiography and was found to be suitable for PTCA. Furthermore, an appropriate bed was available and PTCA team was available. While patients with severe CAD disease such as left main disease may warrant same day procedures, others will less severe disease may have same day procedures simply because the surgical team and a bed were available. Also some patients are seriously ill and require surgery imminently but can wait over a weekend; indeed they may require stabilization. Further, patients who are stable enough to wait longer than 3 days but not longer than one month are believed to be different clinically from patients who can wait 1-3 months. Elective patients may also wait between three months and one year. It was felt that patients who wait over one year are not on a waiting list, but are being treated medically, deteriorate over time and then have the therapeutic procedure.

In this study waiting time was defined as the difference in days between the procedure date of the diagnostic procedure and the therapeutic procedure. The mean waiting time between index angiography and index PTCA was almost three months, that is, 79.9 days (SD $\pm$ = 239.3 days, minimum = 0 days, maximum = 2,140 days, median = 13 days, mode = 0 days). The mean waiting time between index angiography and index CABS was almost five months, that is, 142.8 days (SD ± = 281.7 days, minimum = 0 days, maximum = 2,031 days, median = 36 days, mode = 2 days). Because the distribution was skewed, differences in waiting time by admission category were examined. Data were trimmed at waiting time less than 365 days, because patients who wait over one year were believed to be clinically different than those who wait a shorter period of time. An ANOVA for patients who waited less than a year identified that there was a significant difference in mean waiting time between index angiography and index PTCA for differing admission status ($F=114.5$, $p<.0001$); that is, patients admitted as emergent (x = 14.8 days) or urgent (x = 11.9 days) had significantly shorter mean waiting times than did patients admitted as elective (x = 45.5 days). A significant difference in mean waiting time between index angiography and index CABS for differing admission status was also found ($F=209.7$, $p<.0001$); that is patients admitted as emergent (x = 28.8 days) or urgent (x = 33.5 days) had significantly shorter waiting times than patients admitted as elective (x = 94.1 days).

While waiting time could have been treated as a continuous variable, it was grouped into six clinically relevant time intervals: (a) same day, (b) 1-3 days, (c) 4-30 days, (d) 31-90 days, (e) 91-365 days, and (f) greater than 366 days. Naylor and colleagues (1991) developed and validated (Naylor, Levinton & Baigrie, 1992) an urgency/appropriateness rating scale based on 49 case scenarios. The seven time intervals in that study ranged from 0 days to 6 months. These time intervals did not lend themselves to this study using administrative data, e.g. 'immediate' could not be distinguished from 'within 24 hours'. Also too much data would have been lost if waiting time had been trimmed at six months. Rather, in this study all data were used to determine if any time intervals affected survival.

For the survival analyses, these six clinically relevant time intervals were transformed into dichotomous variables. Three base cases were modelled: (a) 0 days, (b) 1-3 days, and (c) 0-3 days and these results will be reported later.

Description of the Sample

Angiography

The database for the Ischemic Heart Disease population consisted of 11,766 patients who were 25 years of age and over and were followed for the study period of FY 1987/88-1992/93. Table 10 identifies the total number of patients followed and the total number of procedures performed on these patients over the study period. Patients had more than one procedure e.g. a second angiography occurred in 544 patients, 51 patients had a third and 4 patients had a fourth angiography.

Table 10

Number of Coronary Artery Diagnostic and Therapeutic Procedures (FY 1987/88-1992/93)

Number of procedures per person

	1	2	3	4	Total Procedures	Total Persons
Angiography	11,167	544	51	4	12,424	11,766
PTCA	2,080	232	22	0	2,601	2,334
CABS	2,698	5	0	0	2,708	2,703

Using index angiography as a screening procedure for entry into the study, the inclusion criteria consisted of patients who: (a) were Manitoba residents, (b) were 25 years of age and over, and (c) had the procedures performed in Manitoba hospitals. Exclusion criteria were patients who had heart valves or septa repairs (350-3599) during the same admission. There were 10,683 persons who met this inclusion criteria of index diagnostic angiography. It is assumed that the 1083 persons remaining had the procedure prior to the study period, that is prior to FY 1987/88 or that they had the diagnostic procedure performed out of province. Of the 10,683 persons who had index angiography in the study period, 163 had been double counted since they had index angiography and index PTCA on the same day; when these persons were allocated to PTCA, 10,520 persons remained. A further 8 patients had CABS followed by PTCA with no prior angiography; these are likely coding mistakes. Thus, there were a total of 10,512 patients for the denominator of the study. Of these, 2,038 went on to have index PTCA and 2,661 to have index CABS. Figure 1 presents the index procedural experience of the 10,512 persons.

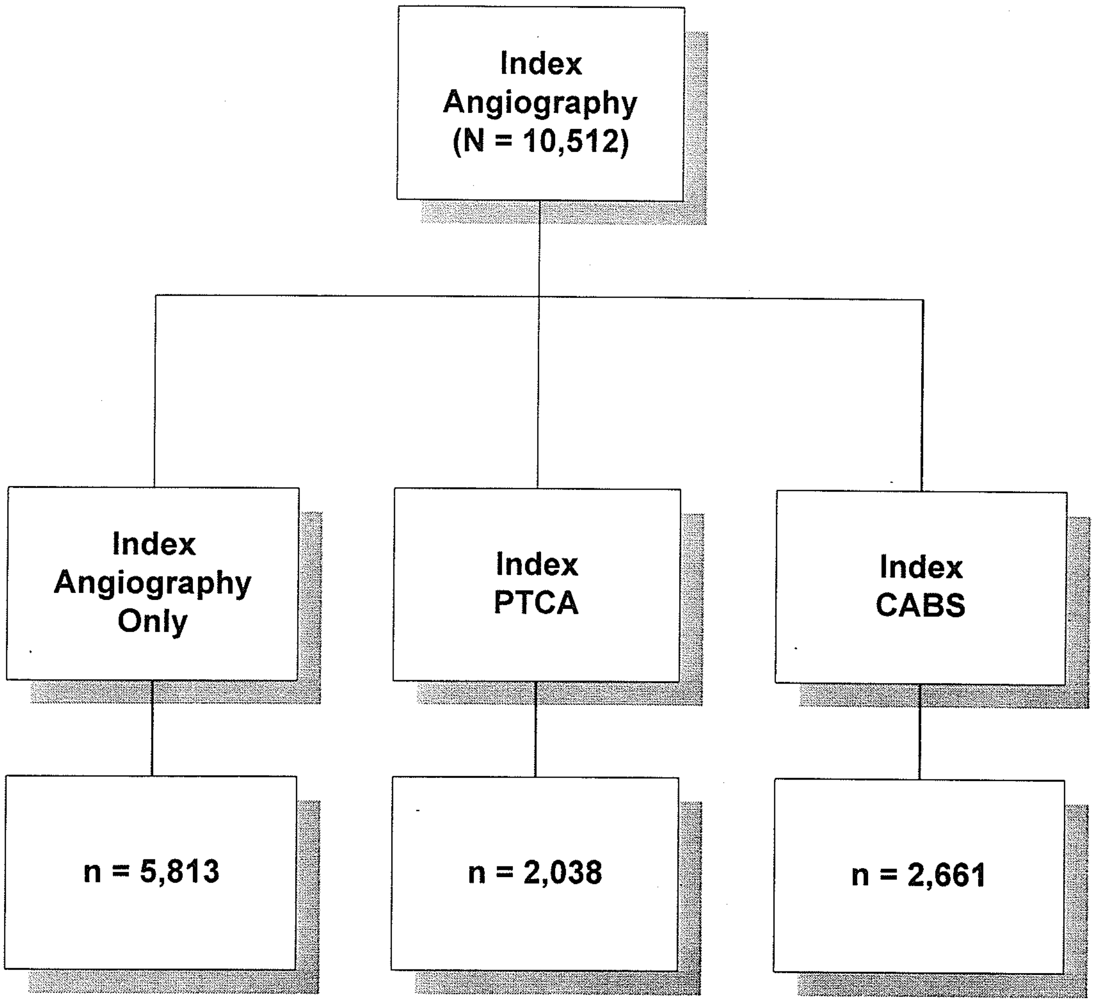

Figure 1. **Procedural outcomes up to six years after index angiography(FY 1987/88-1992/93)**

Revascularization

Having had index angiography, there were 101 possible combinations of procedures for the persons who were followed for the six years of the study. For example, a person could have had index angiography, PTCA, a second angiography and a repeat PTCA over the study period. Thc analysis focuses on those persons who had index angiography and went on to have index CABS or PTCA. The baseline characteristics of angiography patients will be described in chapter 3.

CHAPTER 3

Angiography

Introduction

Angiography is an invasive procedure used to determine the site and extent of coronary artery disease (CAD). If referral bias exists in the sociodemographic or clinical characteristics of angiography patients, this could lead to differential access to Coronary Artery Bypass Surgery (CABS) and Percutaneous Transluminal Coronary Angioplasty. A unique feature of this study is that longitudinal histories were constructed in which angiography was the entrance criterion and all Manitoba residents who had an index angiography were followed from 1987 to 1992 to determine whether they went on to have a PTCA or CABS. As identified in the literature review in Chapter 1, sociodemographic and clinical variables related to utilization of and outcomes associated with CAD procedures, available in the Manitoba Centre for Health Policy and Evaluation (MCHPE) database were the foci of this study. Age was an important variable, since the incidence of CAD is age-related and a shift to increased utilization of coronary surgical procedures in the elderly has been reported (Roos & Sharp, 1989; Anderson et al. 1993). Gender was also investigated because CAD is delayed in women and women have also been reported to experience lower utilization of CAD procedures and more adverse outcomes associated with the procedures. In a province where both CAD diagnostic and therapeutic procedures and physician specialty resources are centralized in two teaching hospitals in Winnipeg, regional access was an important concern. Because the incidence of CAD is related to socioeconomic status, Statistics Canada's data on census tract household income at the enumeration level was also examined. Income quintiles were constructed with 20% of the population in each quintile. Income quintiles were ranked from 1 (low) to 5 (high). Administrative data lack much of the clinical data associated with primary data collection, such as the extent of CAD, but one important clinical variable, comorbidity, was available in the database. Pre-existing comorbid disease can lead to differential outcomes and the Luft and Romano (1992) comorbidity index developed for CABS was used.

Hypotheses

The purpose of this chapter was to determine if differences existed in the baseline characteristics of index angiography patients who met the study inclusion criteria. The inclusion criteria were patients who: (a) were 25 years and older, (b) were residents of Manitoba, and (c) had an index angiography in Manitoba between fiscal year 1987 and 1992. Two types of baseline characteristics were examined: a) sociodemographic, and b) clinical characteristics. As displayed in Table 11, the hypotheses related to sociodemographic characteristics were:

(a) there are no differences in the number of men and women who have angiography,

(b) there are no differences in the mean ages of men and women who have angiography,

(c) there are no differences in the region of residence of men and women who have angiography,

(d) there are no differences in the income quintiles of men and women who have angiography,

(e) there are no regional differences in the number of patients who have angiography,

(f) there are no regional differences in the mean ages of angiography patients,

(g) there are no regional differences in the income quintiles of angiography patients,

(h) there are no differences in the number of angiography patients across income quintiles, and

(i) there are no differences across income quintiles in the mean ages of angiography patients.

Table 11

Hypotheses Related to Baseline Sociodemographic Characteristics of Index Angiography Patients

Variables	Gender (A)	Region (E)	Income (H)
	Age (B)		
	Region (C)	Age (F)	
	Income (D)	Income (G)	Age(I)

Table 12 displays the hypotheses concerning the relationship of the clinical variable, comorbidity, to the sociodemographic characteristics. The hypotheses are:

(j) there are no differences in the mean ages of angiography patients who have comorbidities,

(k) there are no gender differences in comorbidities of angiography patients,

(l) there are no regional differences in the comorbidities of angiography patients, and

(m) there are no differences across income quintiles in the comorbidities of angiography patients.

Table 12

Hypotheses Related to Baseline Clinical Characteristics of Index Angiography Patients

Comorbidities	Congestive Heart Failure	Previous Myocardial Infarction, etc.
Clinical Variables	Age (Ji)	Age (Jii)
	Gender (Ki)	Gender (Kii)
	Region (Li)	Region (Lii)
	Income (Mi)	Income (Mii)

Analysis

Baseline data are presented as mean ± 1 SD for continuous data and counts for discrete data. Comparisons of characteristics between genders was performed using Student's t test for continuous variables and chi-square, x^2 for discrete variables ($p < .05$, two-tailed). To compare characteristics among regions and income quintiles, analysis of variance (ANOVA) was used for continuous variables and x^2 for discrete variables. In making pairwise comparisons following signficant ANOVA results, the Tukey method was used to control the family-wise error rate at 0.05. Only those comorbidities with sufficient cell sizes for chi-square testing are displayed.

Results

Sociodemographic and Clinical Characteristics

Overview. There were 10,520 patients who had an index angiography over the study and important differences in baseline sociodemographic and clinical characteristics were found. Almost two-thirds were men. Women were, on average, three years older than men at angiography, and gender differences in region of residence and income also occurred. The majority were from Winnipeg. More than expected were from Winnipeg and fewer were from the Other Rural and the Western Regions based on the provincial population distribution aged 25 and over. Patients from Other Rural Regions were younger than those from Winnipeg or the Western Region. Fewer patients than expected were from quintiles 1, 4 and 5 and more were from quintiles 2 and 3 based on the regional distribution of income quintiles. Gender, regional and age differences were also found in the distribution of income. Only five comorbidities were recorded in more than 1% of cases and sociodemographic differences occurred within comorbidities.

Gender. The majority (66%) of patients who had index angiography were men; gender differences in all the baseline sociodemographic characteristics were found. The mean ages of men and women who had an index angiography were significantly different (Table 13). A larger percentage of Winnipeg women were referred for index angiography than from the other two regions, while the opposite was found for men. Wealthy women were less likely to have index angiography than their male counterparts.

Table 13

Baseline Sociodemographic Characteristics of Index Angiography Patients, by Gender (FY 1987/88-1992/93)

Variable	Male	Female
Number	6,940 (66%)	3,580 (34%)*
Age (SD±)	60.25 (11.3)	63.1 (11.1)*
Region of Residence		
Other Rural	1,753 (25.3%)	820 (22.9%)
Western	779 (11.2%)	365 (10.2%)
Winnipeg	4,408 (63.5%)	2,395 (66.9%)**
Income Quintile		
Quintile 1	1,175 (17.1%)	797 (22.6%)
Quintile 2	1,469 (21.4%)	765 (21.7%)
Quintile 3	1,447 (21.1%)	722 (20.5%)
Quintile 4	1,318 (19.2%)	669 (19%)
Quintile 5	1,457 (21.2%)	572 (16.2%)*

Note. *$p < .0001$. **$p < .003$.

Hypothesis A: Because previous studies (Rose & Marmot, 1981; Wing, 1988) reported a higher prevalence of CAD in younger men, it was assumed that the absolute number of men referred for index angiography would exceed the number of women. The null hypothesis tested that there would be no differences in the number of men and women who had angiography. The study found that almost two-thirds (66%) of the patients were men and 34% were women ($p < .0001$) and the hypothesis was rejected.

Hypothesis B: Again, because CAD appears earlier in men than in women, it was expected that men would be younger than women at index angiography. The hypothesis tested that men and women who had angiography would be the same age, however women were 2.8 years older than men ($p < .0001$) and the hypothesis was rejected. Overall, the mean age at index angiography was 61.2 years (SD ± 11.3). For men, the mean age was 60.3 years (SD ± 11.3, range = 25-90) while women had a mean age of 63.1 years (SD ± 11.1, range = 25-91).

Percentage of index angiography patients by age group and gender. Disregarding the 25-34 year age group in which there were few cases, the largest percentage of index angiography occurred in men (30%) in the 55-64 age group and in women (38%) in the 65-74 age group (Table 14). At age 35-44, men were 1.5 times more likely than women to have angiography. This male:female difference narrowed with each successive decade until by age 65-74, women were 1.3 times more likely than men to have angiography. By age 75 and over, women were 1.4 times more likely than men to have angiography.

Table 14

Distribution of Index Angiography Patients by Age Group and Gender

	Age Group					
	25-34	35-44	45-54	55-64	65-74	75+
Male %	1.6	8.5	19.1	31.5	30.0	9.4
N	111	588	1,326	2,184	2,080	650
Female %	1.2	5.6	13.6	28.0	38.0	13.5
N	44	202	488	1,002	1,359	483

Note. N = 10,517

Trends over time in utilization of angiography by age. Between 1987 and 1992, the age distribution of angiography patients changed; utilization declined steadily in the younger age group while it increased in the elderly (Figure 2). In 1987, the largest percentage of patients (35.6%) were in the 55-64 age group, 30.4% were in the 65-74 age group and 6.5% were 75 years of age and over. By 1992, the largest percentage of patients (33%) were in the 65-74 age group and 13.9% were 75 years of age or older.

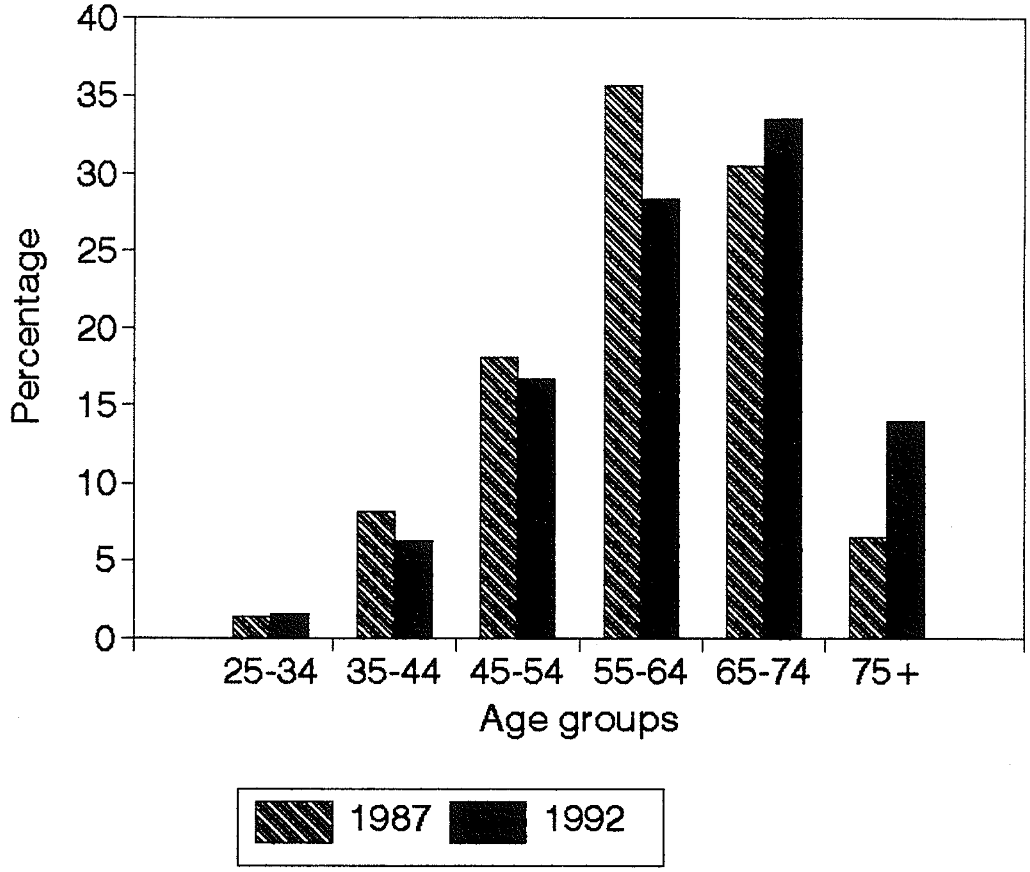

Figure 2. Age distribution difference in index angiography, FY 1987 & 1992

Hypothesis C: While no gender differences in the region of residence were anticipated, women were more likely to be referred for angiography if they were from Winnipeg than if they were from the other two regions, while men were less likely to be referred if they resided in Winnipeg ($p < .003$) and the hypothesis was rejected.

Hypothesis D: Income was not assumed to influence gender utilization of angiography because of Canada's national health insurance. It should be noted that differences in the denominator exist due to: (a) 163 patients who had an angiography and a PTCA on the same day, and (b) 129 patients for whom a postal code used to link to census tract income variables was missing. The smallest percentage of men were in the lowest income quintile while the largest percentage were in the highest quintile. The converse was true for women as the largest percentage of women were in the lowest quintiles and the smallest percentage were in the highest quintile and the hypothesis was rejected ($p < .0001$). Figure 3 shows that as income increased women were less likely to have angiography while men were more likely.

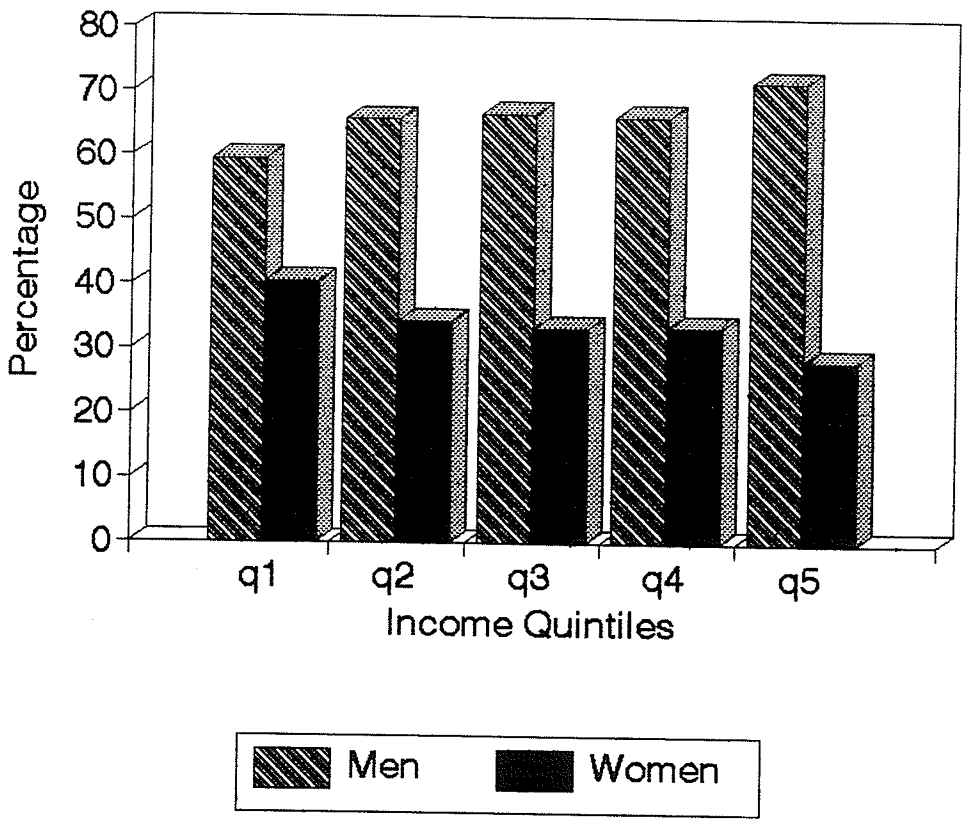

Figure 3. Index angiography income quintile distribution by gender

Region of Residence

Centralization of CAD procedures and specialists in Winnipeg could lead to differential regional access. Regional differences were found with more patients referred from Winnipeg and fewer from the other two regions (Table 15). A larger percentage of the Winnipeg patients were women (Table 13). Patients from Other Rural Regions were younger than those from the other two regions (Table 15). The largest percentage of angiography patients from Winnipeg were from higher income quintiles while the largest percentage of patients from the other two regions were from the lowest income quintiles.

Table 15

Baseline Sociodemographic Characteristics of Indcx Angiography Patients, by Region (FY 1987/88-1992/93)

	Region		
	Other Rural Region	Western Region	Winnipeg Region
Number (%)	2,573 (24.4%)	1,144 (10.9%)	6,803 (64.7%)*
Age (SD±)	59.7 (11.4)**	62.5 (11.0)	61.6 (11.3)
Income			
Quintile 1	593 (23.2%)	371 (32.4%)	1,008 (14.8%)
Quintile 2	673 (26.2%)	452 (39.5%)	1,109 (16.3%)
Quintile 3	697 (27.1%)	175 (15.3%)	1,297 (19.1%)
Quintile 4	427 (16.6%)	111 (9.7%)	1,449 (21.3%)
Quintile 5	151 (5.9%)	31 (2.7%)	1,847 (27.1%)*

Note. *$p < .0001$. **$p < .0002$.

Hypothesis E: The majority (58.6%) of Manitobans reside in Winnipeg, followed by Other Rural Regions (26.6%) and the Western Region (14.8%) and the proportion of patients referred for angiography was expected to reflect this regional population distribution. The hypothesis tested was that there would be no differences in the number of angiography patients from each region. Fewer patients were referred for angiography from Other Rural Regions and the Western Region than from Winnipeg and the hypothesis was rejected ($p < .0001$, Table 15).

Hypothesis F: It was not expected that angiography patients from the three regions would vary by age. An ANOVA identified that Other Rural Region patients were younger than those from the other two regions (F2, 35; $p < .0002$) and that Winnipeg patients were younger than those from the Western Region; the hypothesis was rejected.

Hypothesis G: Regional differences in income distribution were not anticipated but were found amongst all regions and the hypothesis was rejected ($p < .0001$). In Other Rural Regions and the Western Region, the smallest percentage of patients came from the highest income quintile while in Winnipeg the reverse occurred. In Winnipeg there was a positive income gradient; as income increased, so did the percentage of patients having index angiography (Figure 4).

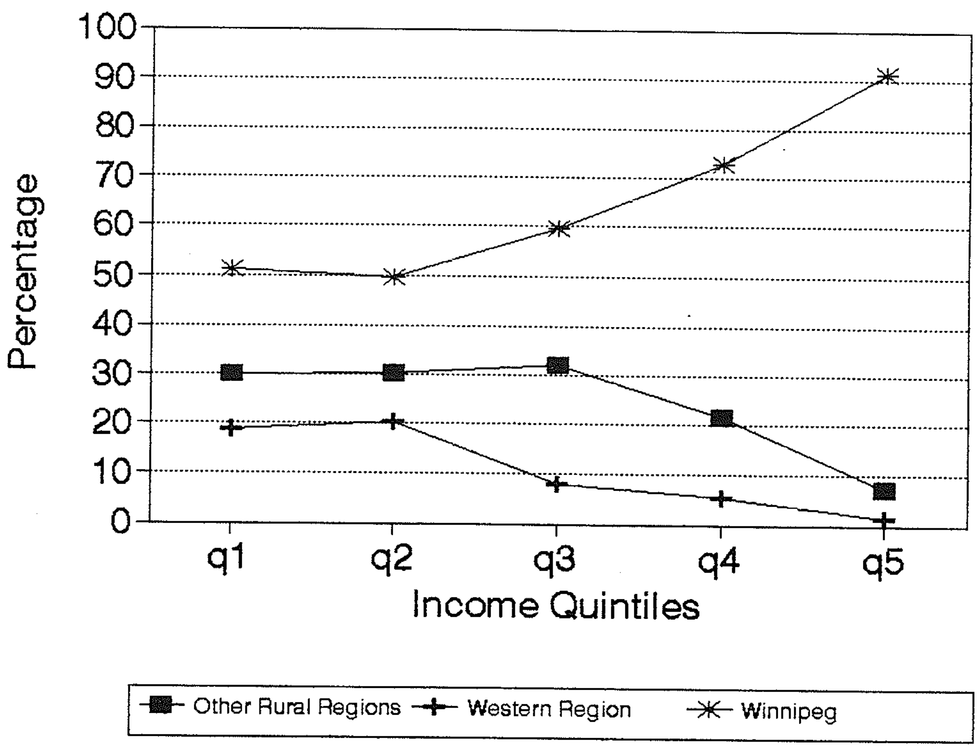

Figure 4. Index angiography income quintile distribution by region

Income

The income distribution of angiography patients differed from the general population aged 25 and over; age differences were also found (Table 16). Gender (Table 13) and regional (Table 15) differences in income have already been noted.

Table 16

Sociodemographic Characteristics of Index Angiography Patients, by Income Quintile (FY 1987-1992)

	Income Quintile				
	1	2	3	4	5
Number	1,972	2,334	2,169	1,987	2,029**
%	18.9	22.4	20.8	19.1	19.5
Age	61.2	62.0	62.3	60.4	59.9*
SD±	12.1	11.3	10.9	11.1	11.0

Note. *$p < .0001$. **$p < .001$.

Hypothesis H: Because the current literature indicates that there is an inverse relationship between CAD and socioeconomic status, more angiography patients were expected to come from the lower income quintiles. By definition, each quintile contains 20% of the population. The hypothesis tested that there would be no differences in the number of patients from each quintile. There were proportionately fewer angiography patients in quintiles 1, 4 and 5 and more in quintiles 2 and 3 than in the general population and the hypothesis was rejected ($p < .001$).

Hypothesis I: The mean age of angiography patients was not expected to vary by income quintile. Patients from quintiles 1, 2 and 3 were significantly older than patients from quintiles 4 and 5 ($p < .0001$).

Comorbidities Only five comorbidities were recorded in more than 1% of the angiography patients. They were: (a) congestive heart failure (9.3%, n = 981), (b) previous myocardial infarction (6.1%, n = 638), (c) diabetes (2.1%, n = 211) as displayed in Table 17; (d) peripheral vascular disease (1.6%, n = 159), and (e) chronic renal failure (1.1%, n = 114) as displayed in Table 18.

Table 17

Comparison of Comorbidities by Sociodemographic Characteristics of Index Angiography Patients (FY 1987/88-1992/93)

	Comorbidities		
	CHF (n = 981)	Old AMI (n = 638)	Diabetes (n = 211)
Gender			
Men	560 (57.1%)	490 (76.8%)	116 (55%)
Women	421 (42.9%)**	148 (23.2%)**	95 (45%)**
Age (SD±)	66.7 (10.9)*	63.0 (10.1)*	59.1 (12.9)++
Region			
Other Rural	191 (19.5%)	116 (18.2%)	55 (26.1%)
Western	108 (11.0%)	90 (14.1%)	17 (8.1%)
Winnipeg	682 (69.%%)**	432 (67.7%)**	139 (65.9%)
Income Quintile			
Quintile 1	273 (28.2%)	93 (14.7%)	60 (29%)
Quintile 2	218 (22.5%)	138 (21.8%)	38 (18.4%)
Quintile 3	210 (21.7%)	151 (23.9%)	49 (23.7%)
Quintile 4	134 (13.8%)	122 (19.3%)	30 (14.5%)
Quintile 5	133 (13.7%)*	128 (20.3%)	30 (14.5%)+

Note. *$p < .0001$. **$p < .001$. +$p < .002$. ++$p < .005$.

Table 18

Comparison of Comorbidities by Sociodemographic Characteristics of Index Angiography Patients (FY 1987-1992)

	Comorbidities	
	Peripheral Vascular Disease (n = 159)	Chronic Renal Failure (n = 114)
Gender		
Men	113 (71.1%)	77 (67.5%)
Women	46 (28.9%)	37 (32.5%)
Age (SD±)	67.1 (9.7)*	59.3 (13.2)
Region		
Other Rural	39 (24.5%)	31 (27.2%)
Western	25 (15.7%)	13 (11.4%)
Winnipeg	95 (59.8%)	70 (61.4%)
Income Quintile		
Quintile 1	22 (13.8%)	30 (26.5%)
Quintile 2	45 (28.3%)	24 (21.2%)
Quintile 3	42 (26.4%)	22 (19.5%)
Quintile 4	27 (17%)	17 (15%)
Quintile 5	22 (13.8)**	20 (17.7%)

Note. *$p < .0001$. **$p < .04$.

Hypothesis J: Although some comorbidities have an age-related onset, the hypotheses tested that there would be no differences in the mean age of angiography patients with and without comorbidities (Tables 17 and 18).

Ji: The mean age of patients with CHF was older than other angiographic patients ($p < .0001$) and the hypothesis was rejected.

Jii: Patients who had a previous myocardial infarction were older than patients without this comorbidity ($p < .001$) and the hypothesis was rejected.

Jiii: The mean age of patients with diabetes was younger than those without this comorbidity ($p < .005$) and so the hypothesis was rejected.

Jiv: Patients with peripheral vascular disease were older than those without this comorbidity ($p < .0001$) and the hypothesis was rejected.

Jv: There was no significant difference in the mean age of patients with chronic renal failure ($p < .1233$) and the hypothesis could not be rejected.

Hypothesis K: While gender differences in patients with and without comorbidities were not expected, the hypotheses tested that there would be no gender differences in patients with and without comorbidities.

Ki: A larger proportion of women were found to have CHF ($p < .001$) and this hypothesis was rejected.

Kii: A larger proportion of men had a previous myocardial infarction ($p < .001$) than those without this comorbidity and the hypothesis was rejected.

Kiii: Diabetic patients were more likely to be female than those angiographic patients without this comorbidity ($p < .001$) and the hypothesis was rejected.

Kiv: There were no gender differences in the proportion of men and women with peripheral vascular disease ($p < .171$) and the hypothesis could not be rejected.

Kv: There were no gender differences in the proportion of men and women with chronic renal failure than in the angiographic population ($p < .721$) and the hypothesis could not be rejected.

Hypothesis L: It was assumed that angiography patients with comorbidities would not be distributed differently across the regions than those without comorbidities and five hypotheses were tested.

Li: There were proportionately fewer patients with CHF from the Rural Region and more from Winnipeg and the hypothesis was rejected ($p < .001$).

Lii: Proportionately fewer patients from the Rural Region had a previous myocardial infarction while more from the Western Region and Winnipeg had ($p < .0001$) and the hypothesis was rejected.

Liii: The proportions of patients with and without diabetes did not differ by region of residence ($p < .397$) and the hypothesis could not be rejected.

Liv: No regional differences were found in the distribution of patients with peripheral vascular disease ($p < .129$) and the hypothesis could not be rejected.

Lv: Regional differences in the proportion of patients with chronic renal failure were not detected ($p < .751$) and the hypothesis could not be rejected.

Hypothesis M: It was postulated that patients with comorbidities would not be distributed across different income quintiles than those without comorbidities and five hypotheses were tested.

Mi: Proportionately more patients from quintiles 1, 2 and 3 and fewer from quintiles 4 and 5 had CHF and the hypothesis was rejected ($p < .0001$).

Mii: No differences in the income distribution of patients with previous myocardial infarction were found ($p < .073$) and the hypothesis could not be rejected.

Miii: Proportionately more patients from quintile 1 and 3 and fewer from quintiles 2, 4 and 5 had diabetes ($p < .002$) and the hypothesis was rejected.

Miv: Proportionately fewer patients from quintiles 1, 4 and 5 and more from quintiles 2 and 3 had peripheral vascular disease ($p < .038$) and the hypothesis was rejected.

Mv: No differences in the income distribution of patients with chronic renal failure were found ($p < .430$) and the hypothesis could not be rejected.

Discussion

Sociodemographic Characteristics

Gender

Gender differences were found in all sociodemographic variables except the one expected: age. While women were less likely than men to be referred for angiography, it is unlikely that these gender differences in referral patterns indicate that men have more appropriate indicators for angiography. It should be noted that appropriateness cannot be determined from the database because it does not contain the results of angiography. Rather, because CAD is age-related and presents later in women due to the protective effect of estrogen, the literature reports that fewer absolute numbers of women receive CAD procedures. This study found a shift in gender utilization with age; at age 35-44, one third (34%) more men than women were referred for angiography, but by age 65, twenty percent (21%) more women than men were referred. Women, were on average, almost three years older than men at referral for angiography.

Women who had angiography were distinctly different than men in region of residence and income. A smaller percentage of women who resided outside Winnipeg were referred for index angiography. While it is possible that rural women declined angiography more often than their Winnipeg counterparts, it is more likely that they were not being referred as often. On the other hand, whether the larger percentage of women from Winnipeg referred for angiography indicates an aggressive approach or inappropriate referral can not be determined from this data.

Inexplicably, women from the highest income quintiles were less likely to be referred for angiography but the converse was true for men. Since the literature reports an inverse relationship between income and CAD, the finding that a larger percentage of men from the highest income quintile were referred for angiography is atypical and will be addressed in the section dealing with the variable, income, later in this chapter.

Age

In keeping with the later onset on CAD in women due to the protective effect of estrogen, women were almost three years older than men at index angiography and the age-related utilization of angiography reflected the natural history of CAD. Younger men were more likely than women to have angiography but by age 65 and over, the percentage of women having angiography was greater than men. Of men who had an angiography, the largest percentage (31.5%) had the procedure at age 55-64, while the largest percentage of women (38%) had the procedure at age 65-74.

A shift in utilization by age occurred over the course of the study. Angiography utilization increased by 10% in the elderly and decreased by 10% in the non-elderly. These results are in keeping with the findings from the Rates chapter (6), where increases over time were found in all age groups with the largest increase in the 75 and older age group. This shift to increased utilization in the elderly reflects the increased growth in the elderly in the population. Between 1976 and 1991, the provincial population grew by 5% to 1,133,117, however all age groups except those over 65 years of age decreased. The population aged 65-74 increased by 20% while the population aged 75 years of age and over increased by 30% (Manitoba Health Services Commission, 1976, 1991).

Region of Residence

In a province in which cardiac services are centralized in the two teaching hospitals in Winnipeg, access to these services from outside Winnipeg is critical. In comparison to the regional distribution of the general population aged 25 and over, there were fewer patients from Other Rural Regions and the Western Region and more from Winnipeg referred for angiography. It is may be that this regional variation represents a differential technology diffusion rate outside Winnipeg or differences in patient preferences but these explanations are not as likely as that of regional differential referral patterns. This data does not address appropriateness of referral and underutilization of angiography outside Winnipeg is just as plausible as overutilization within Winnipeg.

Since angiography is a screening procedure for CABS and PTCA, it will be interesting to determine whether this regional referral bias and differential access also is found in the therapeutic procedures.

As already reported, regional differences in the proportion of women being referred for angiography existed with a larger percentage of women from Winnipeg referred than from the other two regions. Further, a larger percentage of women than men were referred from Winnipeg. Regional age differences were found with patients from the Other Rural Regions referred at a younger age than those from the Western Region or Winnipeg. Patients from the Western Region were oldest at referral for angiography.

Regional differences in the income distribution of angiography patients were found, but not in the direction expected. The literature indicates that an inverse relationship between income and ischemic heart disease (IHD) exists, with patients from lower socioeconomic status (SES) having a higher prevalence of IHD while those from higher SES have a lower prevalence. In the Other Rural Region and the Western Region, angiography utilization reflected this reported income-utilization relationship as patients from the lowest income quintile were referred more often for angiography than patients from the highest income quintile. However in Winnipeg the opposite occurred; not only were patients from the lowest income quintile referred for angiography less often than patients from the highest income quintile, a positive income gradient was found. This finding generates serious concern. The finding that, in Winnipeg, as wealth increased so did utilization, contradicts the literature and may indicate increased patient demand. If Winnipeg patients with less severe CAD from wealthier neighbourhoods are less willing to tolerate angina symptoms and are requesting angiography, two fundamental questions remain to be addressed. The first question is whether patients from poorer neighbourhoods in Winnipeg are being denied access to angiography. If finite resources are maldistributed because of differential access, this is a serious concern. Only a waiting list which also includes information about SES could directly address this question. Conversely, if patients from poorer neighbourhoods in Winnipeg were found not to be denied access, this may indicate excess resource capacity. The second question is whether the indications for angiography in the Winnipeg wealthy are appropriate. While appropriateness of angiography cannot be answered with the data available in this database, a chart audit using appropriateness rating criteria is recommended to resolve this issue.

Income

There were differences in the distribution of angiography patients across income quintiles from that of the general population but not in the direction that was expected from the literature. An inverse relationship between socioeconomic status and CAD has been reported but this study found that there were more angiography patients from quintiles 2 and 3 and fewer from quintiles 1, 4 and 5. An unexpected finding was that fewer of the poorest patients are referred for angiography. Since there is no incentive for physicians not to refer with national health insurance, other reasons may exist. Perhaps patients from the poorest neighbourhoods had poor CAD risk factors, such as smoking history, obesity, elevated cholesterol levels, etc.; risk factor profiles cannot be determined from this data. Perhaps patients from the poorer neighbourhoods declined angiography more frequently because of different expectations of health. While this finding generates serious concern, reasons for it can only be speculative.

Baseline differences in all sociodemographic variables between the highest and the lowest income quintiles were found. As noted above, a gender differential was found in income distribution with women from poorer neighbourhoods and men from wealthier neighbourhoods more likely to receive angiography. While the income distribution of women across income quintiles reflects the relationship between CAD and income reported in the literature, the difference in referral between lowest and highest income men does not. Differences were found in the mean ages of patients across income quintiles; patients from quintiles 1, 2 and 3 were older than patients from quintiles 4 and 5. As addressed earlier, patients from wealthier neighbourhoods in Winnipeg were also more likely to receive angiography than patients from wealthier neighbourhoods in the other two regions. If access to services is not associated with ability to pay in systems with national health insurance, and an inverse relationship is reported between CAD and income is reported, how can we interpret these findings? Clearly younger, male patients from wealthier Winnipeg neighbourhoods have increased access to angiography. This data cannot indicate whether this utilization pattern is appropriate and angiography is underutilized in all other patients. It may be that increased patient demand is occurring from Winnipeg men from wealthier neighbourhoods. These men may be unwilling to tolerate symptoms and may be more knowledgeable about treatment modalities.

Clinical Characteristics

Comorbidities

Patients with comorbid disease may have decreased probability of survival after therapeutic procedures and so describing and adjusting for comorbid disease is important. As identified in Chapter 2, the Luft and Romano comorbidities which were designed specifically for investigation of CABS outcomes were used. The diagnosis, previous myocardial infarction, was added to the comorbidities in order to assess its descriptive and predictive capability. Because the MCHPE database lacks a severity scoring system, comorbidities are the only modifier of diagnoses currently available to the researcher.

Only five comorbidities occurred in at least 1% of the cases. They were: (a) congestive heart failure (9.4%, n = 981), (b) previous myocardial infarction (6.1%, n = 638), (c) diabetes (2.1%, n = 211), (d) peripheral vascular disease (1.6%, n = 159), and (e) chronic renal failure (1.1%, n = 114). It is not known whether the infrequent occurrence of comorbidities was due to poor recording practices or narrow selection processes. Because angiography is available on an outpatient basis, less frequent recording of comorbidities is speculated as physicians may tend to record comorbidities more to explain/describe inpatient length of stay.

Baseline differences in the distribution of sociodemographic variables occurred across comorbidities. While patients with comorbidities were expected to be the same age as those without comorbidities, this study found that patients with diabetes were younger than those without the condition, while patients with CHF, previous myocardial infarction and peripheral vascular disease were older. Only patients with chronic renal failure did not differ in mean age from the remainder of the angiographic population.

Gender differences were found in three comorbidities; CHF and diabetic patients were more likely to be women, while patients with previous myocardial infarctions were more likely to be men. No gender differences were found in patients who had peripheral vascular disease or chronic renal failure.

Regional differences in the distribution of comorbidities were unanticipated and the findings were complex. No regional differences were found in the distribution of diabetes, peripheral vascular disease or chronic renal failure; proportionately fewer Rural Region patients and more Winnipeg patients had CHF. For myocardial infarction, proportionately fewer Rural Region patients and more Western Region and Winnipeg patients had this comorbidity.

Income differences in the distribution of comorbidities were not expected and none were found for patients with previous myocardial infarction or chronic renal failure. The findings for the remaining three comorbidities were more complicated. Angiography patients from the poorest neighbourhoods were more likely to have CHF than those from the two top income quintiles. While socioeconomic differences were detected in the distribution of diabetes and peripheral vascular disease, looking only at the extreme income quintiles, more patients from the least affluent neighbourhoods had diabetes, while fewer peripheral vascular disease patients came from both the least and most affluent neighbourhoods.

CHAPTER 4

Percutaneous Transluminal Coronary Angioplasty

Introduction

This study constitutes the first analysis of PTCA in Manitoba. PTCA was first performed in Manitoba in 1985. As identified in the literature review in Chapter 1, sociodemographic and clinical data related to utilization of and outcomes associated with CAD procedures, available in the Manitoba Centre for Health Policy and Evaluation (MCHPE) database were examined. Age was an important variable, since originally PTCA guidelines suggested that the procedure be performed only in patients under 60 years of age. Large numbers of observational studies have established the feasibility of PTCA in the elderly. Initial patency rates and long-term survival are satisfactory, however perioperative mortality and morbidity is elevated in the elderly (Johansson, Brorsson & Bernstein, 1994). A shift to increased PTCA utilization in the elderly has been noted in other jurisdictions (Hilbourne, Leape, Kahan, Park, Kamberg, & Brook, 1991) and the trends in Manitoba were important to assess. The efficacy of PTCA for women has been controversial. The survival rates and revascularization rates have varied in numerous studies and gender differences in PTCA utilization and outcomes were important to analyze in Manitoba. In a province where both CAD diagnostic and therapeutic procedures and physician specialty resources are centralized in two teaching hospitals in Winnipeg, regional access was an important concern. Because the incidence of CAD is related to socioeconomic status, Statistics Canada's census data on household income at the enumeration level was also examined. Administrative data lack much of the clinical data associated with primary data collection, such as the extent of CAD, but two important clinical variables were available and examined. Pre-existing comorbid disease can lead to differential outcomes and the Luft and Romano (1992) comorbidity index developed for CABS was used. A unique feature of this study was the quantification of waiting time between index angiography and index CABS or PTCA. Countries with national health insurance are often purported to have increased waiting time for access to services but, to date, objective data has been lacking to substantiate or refute this claim.

Hypotheses

The purpose of this chapter is to determine: (a) whether the baseline characteristics of index PTCA patients who met the study inclusion criteria vary, and (b) if these characteristics predict survival. The inclusion criteria were patients who: (a) were 25 years and older, (b) were residents of Manitoba, and (c) had an index angiography in Manitoba between fiscal year 1987 and 1992. Patients who met the inclusion criteria were followed from fiscal year 1987 to 1992 to determine whether they subsequently had an index PTCA and/or and index CABS. This chapter reports on the patients who had an index PTCA.

Two types of baseline characteristics of PTCA patients were examined: (a) sociodemographic, and (b) clinical characteristics. As displayed in Table 19, the hypotheses related to sociodemographic characteristics were:

(a) there are no differences in the number of men and women who have PTCA,

(b) there are no differences in the mean ages of men and women who have PTCA,

(c) there are no differences in the region of residence of men and women who have PTCA,

(d) there are no differences in the income quintiles of men and women who have PTCA,

(e) there are no regional differences in the number of patients who have PTCA,

(f) there are no regional differences in the mean ages of PTCA patients,

(g) there are no regional differences in the income quintiles of PTCA patients,

(h) there are no differences in the number of PTCA patients across income quintiles, and

(i) there are no differences across income quintiles in the mean ages of PTCA patients.

Table 19

Hypotheses Related to Baseline Sociodemographic Characteristics of Index PTCA Patients

Variables	Gender (A)	Region (E)	Income (H)
	Age (B)		
	Region (C)	Age (F)	
	Income (D)	Income (G)	Age (I)

Table 20 displays the hypotheses concerning the relationship of the clinical variables, comorbidities and waiting time, to sociodemographic characteristics. The hypotheses are:

(j) there are no differences in the mean ages of PTCA patients who have comorbidities,

(k) there are no gender differences in comorbidities in PTCA patients,

(l) there are no regional differences in the comorbidities of PTCA patients,

(m) there are no differences across income quintiles in the comorbidities of PTCA patients,

(n) there are no differences in the comorbidities of PTCA patients by time interval between index angiography and index PTCA,

(o) there are no differences in the mean ages of PTCA patients by time interval between index angiography and index PTCA,

(p) there are no differences in the time interval between index angiography and index PTCA of men and women,

(q) there are no regional differences in the time interval between index angiography and index PTCA of PTCA patients, and

(r) there are no differences across income quintiles in the time interval between index angiography and index PTCA of PTCA patients.

Table 20

Hypotheses Related to Baseline Clinical Characteristics of Index PTCA Patients

	Clinical Variables	
Sociodemographic Variables	Comorbidities	Time
	Age (J)	
	Gender (K)	Age (O)
	Region (L)	Gender(P)
	Income (M)	Region(Q)
	Time (N)	Income(R)

Finally, the impact of both the sociodemographic and clinical characteristics on survival of PTCA patients was hypothesized. The relative survival of PTCA patients was contrasted with that of CABS patients and will be reported in Chapter 5. The hypotheses tested are repeated here:

(s) there are no differences in the survival of CABS and PTCA patients,

(t) there are no gender differences in the survival of CABS and PTCA patients,

(u) there are no age differences in the survival of CABS and PTCA patients,

(v) there are no differences in the survival of CABS and PTCA patients adjusting for waiting time, and

w) there are no differences in the survival of CABS and PTCA patients adjusting for gender, mean age, region of residence, income quintiles, comorbidities or time between index angiography and index CABS or PTCA.

Analysis

Baseline data are presented as mean ± 1 SD for continuous data and counts for discrete data. Comparisons of characteristics between genders was performed using Student's t test for continuous variables and x^2 for discrete variables ($p < .05$, two-tailed). To compare characteristics among regions, income quintiles and waiting time, ANOVA was used for continuous variables and x^2 for discrete variables. In making pairwise comparisons following significant ANOVA results, the Tukey method was used to control the family-wise error rate at 0.05. Only those comorbidities with sufficient cell sizes for chi-square testing are displayed. The survival analysis will be described in Chapter 5.

Results

Sociodemographic and Clinical Characteristics

Overview

There were 2,130 (20.2%) patients who had an index PTCA after an index angiography during the six years of the study. Of these, 304 (14.3%) went on to have a second PTCA, 61 (20.1%) had a third PTCA and 6 (9.8%) had a fourth PTCA. Of the patients who had an index PTCA, the majority were men. Gender differences occurred in all sociodemographic characteristics. While the mean age at index PTCA was 60.2 years, women were on average six years older than men. Winnipeg was the region of residence for the majority of PTCA patients. There were more PTCA patients from Winnipeg and fewer from Other Rural Regions and the Western Region than would have been expected based on the provincial population distribution of adults aged 25 and over. There were no differences in the income distribution of PTCA patients relative to the general population. There were few comorbidities recorded for PTCA patients; of the fifteen possible comorbidities, only three occurred in over 1% of the cases. Two-thirds of patients had their PTCA within 30 days of their index angiography.

Gender

Gender differences were found in all pre-procedural baseline sociodemographic variables (Table 21). Fewer women had PTCA than men and women were older, from poorer neighbourhoods and more likely to reside in Winnipeg than men.

Table 21

Baseline Sociodemographic Characteristics of Index PTCA Patients, by Gender (FY 1987-1992)

	Male	Female
Number (%)	1,502 (70.5 %)	628 (29.5%)*
Age (SD±)	58.5 (11.2)	64.4 (10.1)**
Region of Residence		
Other Rural (%)	347 (23.1%)	114 (18.2%)
Western (%)	155 (10.3%)	62 (9.8%)
Winnipeg (%)	1,000 (66.6%)	452 (72%)+
Income Quintile		
Quintile 1 (%)	255 (17.2%)	123 (19.9%)
Quintile 2 (%)	275 (18.5%)	137 (22.2%)
Quintile 3 (%)	302 (20.3%)	126 (20.4%)
Quintile 4 (%)	317 (21.4%)	124 (20%)
Quintile 5 (%)	335 (22.6%)	108 (17.5%)*

Note. *$p < .0001$. **$p < .001$. +$p < .03$.

Hypothesis A: Previous studies identified that men had PTCA more frequently than women (Johansson, 1994). While the null hypothesis stated that there would be no differences in the number of men and women who had PTCA, almost three-quarters (70.5%) of the patients were men and 29.5% were women ($p < .001$) and the hypothesis was rejected (Table 21). The male: female ratio remained stable over the study period, except for a fluctuation in 1990, when the percentage of men decreased to 65.5% and the percentage of women increased to 34.5%. Angiography patients were more likely to have CABS than PTCA after index angiography ($p < .00001$).

Hypothesis B: Coronary artery disease manifests itself earlier in men than in women and it was expected that men would be younger than women at index PTCA. The hypothesis tested was that PTCA men and women would be the same age, however it was found that women were almost six years older than men ($p < .004$) and the hypothesis was rejected (Table 21). Again the findings of this study support the age-related incidence of CAD reported in the literature. Overall, the mean age at index PTCA was 60.2 years (SD $\pm$ 11.2). For men, the mean age was 58.5 years (SD $\pm$ 11.2, range = 24-94) while for women the mean age was 64.4 years (SD $\pm$ 10.1, range = 31-91).

Percentage of index PTCA patients by age group and gender. Men had a greater probability of proceeding from index angiography to index PTCA than women ($p < .001$). When age was included (disregarding the 25-34 year age group in which there were few cases), the highest percentage of index PTCA occurred in men aged 55-64 years and in women aged 65-74 years (Table 22). At age 35-44, men were over two and a half (2.7) times more likely than women to have PTCA. This male: female difference narrowed with each successive decade until by age 65-74, men were less (0.6) likely than women to proceed to PTCA. As age increased there was a monotonic increase in the percentages of both men and women having PTCA, until age 65 and over in men and age 75 and over in women, when the percentages declined.

Table 22

Percentage of Index PTCA Patients by Age Group and Gender

	Age groups					
	25-34	35-44	45-54	55-64	65-74	75+
Male%	1.5	10.2	23.9	31.3	26.4	6.7
N	23	153	359	470	396	100
Female %	0.3	3.8	12.3	26.8	42.8	14.0
N	2	24	77	168	269	88

Trends over time in utilization of PTCA by age. Between 1987 and 1992, there was a 10% decrease in the relative utilization of PTCA in the under 65 year age group (from 66.6% of all PTCA in 1987 to 56.2% in 1992 and a 10% increase in the 65 and older age group (from 33.4% in 1987 to 43.8% in 1992). Figure 5 displays the difference in age distribution in index PTCA between 1987 and 1992.

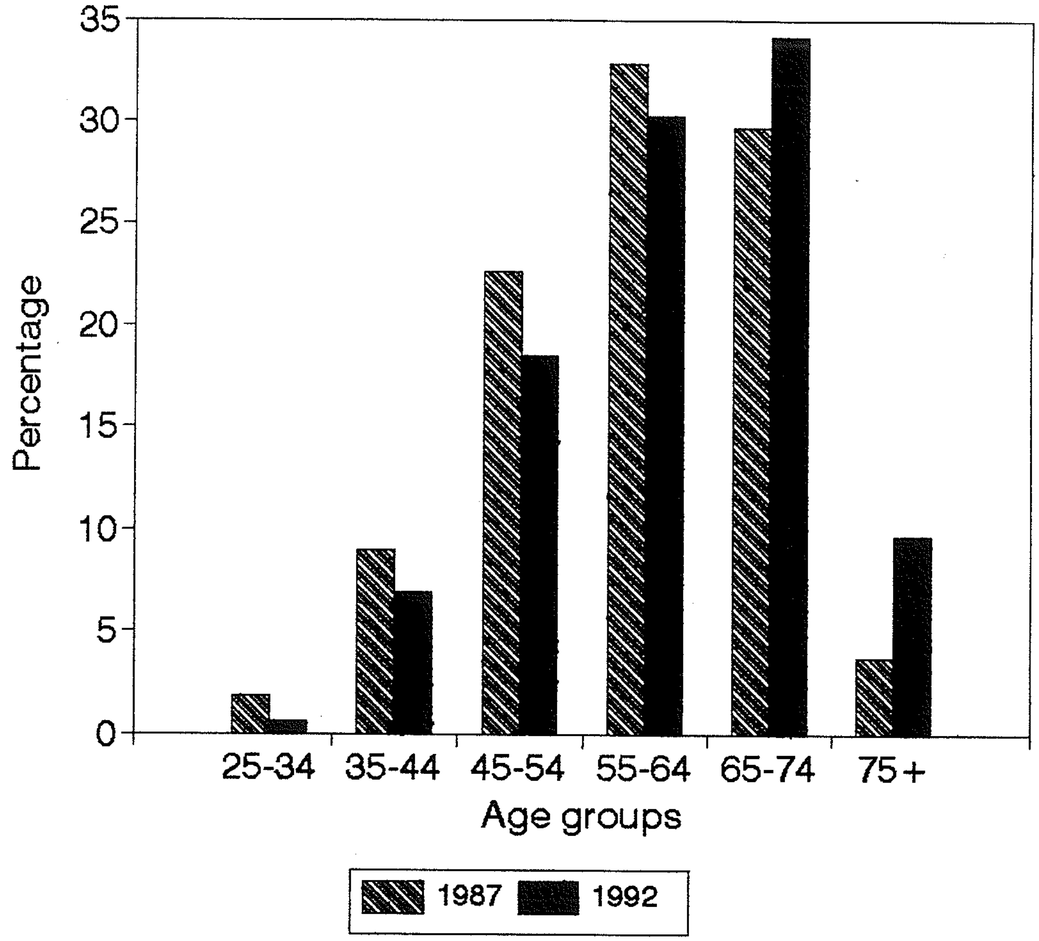

Figure 5. Difference in age distribution in index PTCA between 1987 & 1992

Hypothesis C: While no gender differences in the region of residence were anticipated, a larger percentage of women than men referred for PTCA resided in Winnipeg ($p < .03$) and the hypothesis was rejected.

Hypothesis D: Because of national health insurance, income was not assumed to have a bearing on whether or not men and women had PTCA, however in the lower income quintiles more women had PTCA than men and in the upper quintiles more men had PTCA than women and so the hypothesis was rejected ($p < .0001$). Figure 6 shows that men and women had different PTCA utilization patterns depending upon their income quintiles; as income increased women were less likely to have PTCA while men were more likely.

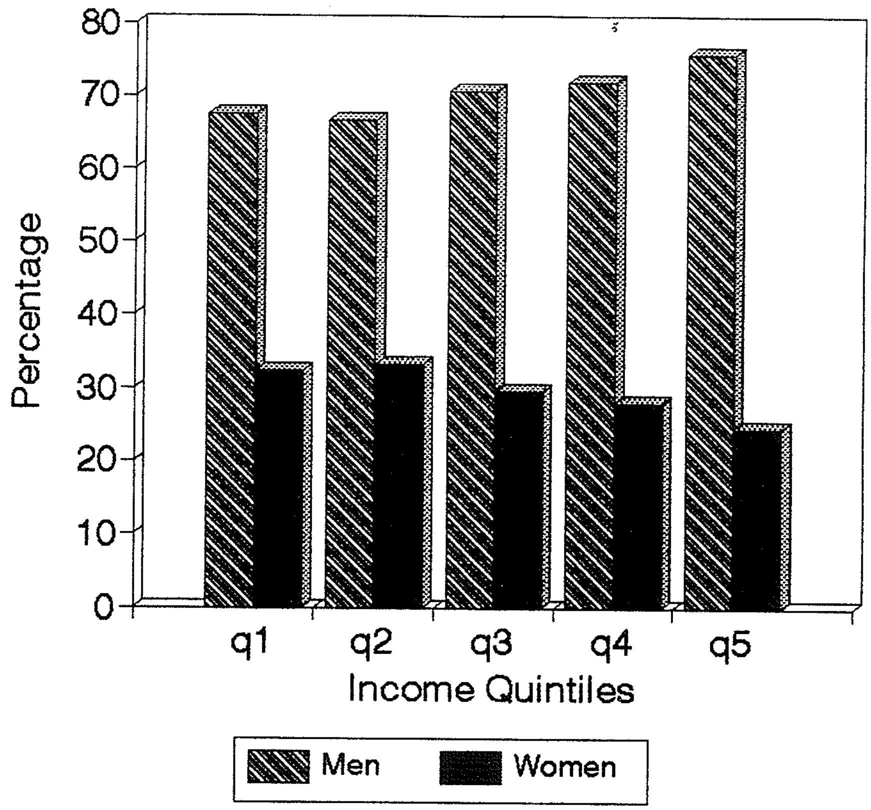

Figure 6. Index PTCA income quintile distribution by gender (FY 1987-1992)

Region of Residence

Centralization of both CAD diagnostic and therapeutic procedures and physician specialists in Winnipeg could lead to differential regional access. Regional differences in the numbers of PTCA patients were found with more patients from Winnipeg and fewer from Other Rural Regions and the Western Region (Table 23). It has already been noted that a larger percentage of women and a smaller percentage of men from Winnipeg had PTCA (Table 21). No regional differences in the mean ages of PTCA patients were found (Table 23). The largest percentage of PTCA patients from Winnipeg were from higher income quintiles while the largest percentage of patients from the other two regions were from the lowest income quintiles.

Table 23

Baseline Sociodemographic Characteristics of Index PTCA Patients, by Region (FY 1987/88-1992/93)

	Other Rural Region	Western Region	Winnipeg Region
Number (%)	461 (21.6%)	217 (10.2%)	1,452 (68.2%)*
Age (SD±)	58.6 (10.6)	62.0 (10.9)	60.5 (11.4)
Quintile 1 (%)	110 (24.1%)	77 (35.8%)	191 (13.4%)
Quintile 2 (%)	100 (21.8%)	79 (36.7%)	233 (16.3%)
Quintile 3 (%)	122 (26.6%)	35 (16.3%)	271 (19%)
Quintile 4 (%)	93 (20.3%)	19 (8.8%)	329 (23%)
Quintile 5 (%)	33 (7.2%)	5 (2.3%)	405 (28.3%)**

Note. *$p < .0001$. **$p < .001$.

Hypothesis E: The majority (58.6%) of the Manitoba population aged 25 and over reside in Winnipeg, followed by Other Rural Regions (26.6%) and the Western Region (14.8%) and the proportion of patients referred for PTCA was expected to reflect the population distribution. The null hypothesis tested was that there would be no differences in the number of PTCA patients from each region. In comparison to the population distribution of adults 25 years of age and over, proportionately more PTCA patients were from Winnipeg and fewer were from Other Rural Regions and the Western Region ($p < .0001$) and the hypothesis was rejected (Table 23).

Hypothesis F: It was not expected that PTCA patients from the three regions would vary by age. While patients from Other Rural Regions were younger than patients from the Western region and Winnipeg, this difference was not significant ($p < .05$) and the hypothesis could not be rejected.

Hypothesis G: Regional differences in income distribution were not anticipated. Figure 7 displays that outside Winnipeg, as income increased, utilization decreased. Within Winnipeg, as income increased so did utilization ($p < .0001$) and the hypothesis was rejected (Table 23).

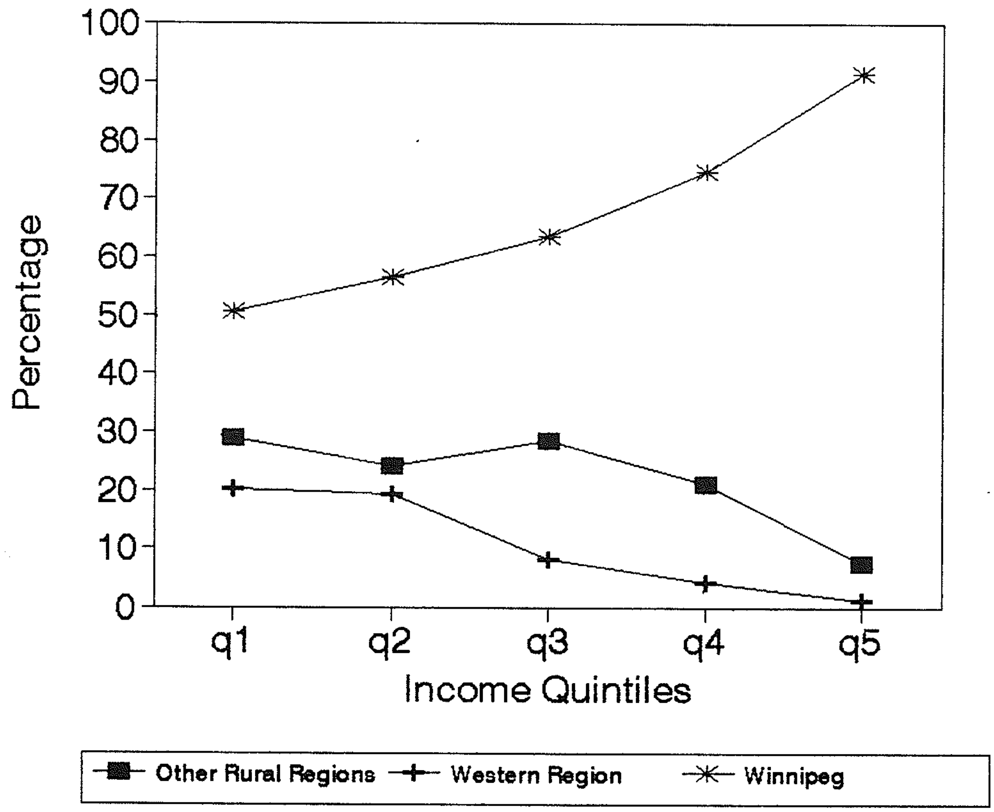

Figure 7. Index PTCA income quintile distribution by region (FY 1987-1992)

Income

No differences in the income distribution of PTCA patients from that of the general population aged 25 and over were found. No differences in the mean ages of patients across income quintiles were found (Table 24). Previously, it has been shown that more female PTCA patients were from the lower income quintiles while more male patients were from the upper income quintiles (Table 23) and that more Winnipeg patients were from the higher income quintiles (Table 21).

Table 24

Sociodemographic Characteristics of Index PTCA Patients, by Income Quintile (FY 1987/88-1992/93)

	Income Quintile				
	1	2	3	4	5
Number	378	412	428	441	443
%	18	19.6	20.4	21.0	21.1
Age	59.9	61.8	61.1	59.4	59.1
SD±	12.3	10.4	10.7	11.0	11.2

Hypothesis H: Based on current literature which indicates that there is an inverse relationship between CAD and socioeconomic status, a larger percentage of PTCA patients were expected to come from the lower income quintiles. By definition, quintile construction places 20% of the population into each quintile. The hypothesis tested that there would be no difference in the percentage of PTCA patients across income quintiles; none was found ($p < .2$) and the hypothesis could not be rejected.

Hypothesis I: The mean ages of PTCA patients was not expected to vary by income quintile. No differences were found ($p < .05$) and it was not possible to reject the hypothesis (Table 24).

Comorbidities

Only three comorbidities occurred in more than 1% of PTCA patients: (a) previous myocardial infarction (10%, n = 213), (b) congestive heart failure (5.6%, n = 120), and (c) diabetes (1.3%, n = 27). Baseline sociodemographic characteristics of PTCA patients varied with different comorbidities. The recorded incidence of diabetes and congestive heart failure was higher in women while the incidence of previous myocardial infarction was higher in men. Patients with congestive heart failure were older than those without this comorbidity (Table 25). Regional differences in the distribution of previous myocardial infarction were found, while income differences in the distribution of congestive heart failure patients were also noted. Congestive heart failure patients waited less time between index angiography and index PTCA than those without this comorbidity while previous myocardial infarction patients waited more time.

Table 25

Comparison of Comorbidities by Sociodemographic Characteristics of Index PTCA Patients (FY 1987/88-1992/93)

	Comorbidities		
	Old AMI (n = 213)	CHF (n = 120)	Diabetes (n = 27)
Age (SD±)	59.5 (10.5)	66.58 (11.7)*	62 (9.7)
Men (%)	165 (77.5%)++	61 (50.8%)	12 (44.4%)
Women (%)	48 (22.5.6%)	59 (49.2%)**	15 (55.6%)**
Other Rural (%)	34 (16%)	19 (15.8%)	2 (7.4%)
Western (%)	29 (13.6%)	13 (10.8%)	3 (11.1%)
Winnipeg (%)	150 (70.4%)+	88 (73.3%)	22 (81.5%)
Quintile 1 (%)	31 (14.6%)	37 (30.8%)	4 (15.4%)
Quintile 2 (%)	42 (19.7%)	20 (16.7%)	2 (7.7%)
Quintile 3 (%)	51 (23.9%)	20 (16.7%)	5 (19.2%)
Quintile 4 (%)	45 (21.2%)	19 (15.8%)	8 (30.8%)
Quintile 5 (%)	43 (20.2%)	23 (19.2%)**	7 (26.9%)
0 Days (%)	9 (4.3%)	26 (22.4%)	3 (11.1%)
1-3 Days (%)	19 (9.1%)	23 (19.8%)	5 (18.5%)
4-30 Days (%)	79 (37.8%)	45 (38.8%)	9 (33.3%)
31-90 Days (%)	50 (23.9%)	5 (4.3%)	3 (11.1%)
91-365 Days (%)	35 (16.8%)	7 (6%)	5 (18.5%)
365+ Days (%)	17 (8.1%)*	10 (8.6%)*	2 (7.4%%)

Note. *$p < .0001$. **$p < .001$. +$p < .01$. ++$p < .05$.

Hypothesis J: Pre-existing comorbid disease can lead to differential outcomes and baseline differences in comorbidities was of interest. It was anticipated that the mean age of PTCA patients with comorbidities would be the same as those without comorbidities and three hypotheses were tested (Table 25).

Ji: No differences in the mean ages of patients with previous myocardial infarction ($p < .3$) were found and the hypothesis could not be rejected.

Jii: Patients with CHF were significantly older ($p < .0001$) than patients without comorbidities and the hypothesis was rejected.

Jiii: No differences in the mean ages of PTCA patients with and without diabetes ($p < .4$) were found and the hypothesis could not be rejected.

Hypothesis K: Gender is often an independent risk factor for disease and hypotheses concerning gender differences in three comorbidities were tested (Table 25).

Ki: Patients with previous myocardial infarction were more likely to be male ($p < .02$) and the hypothesis was rejected.

Kii: Patients with congestive heart failure were more likely to be female ($p < .0001$) and the hypothesis was rejected.

Kiii: PTCA patients with diabetes were more likely to be female ($p < .001$) and the hypothesis was rejected.

Hypothesis L: It was assumed that PTCA patients with comorbidities would not be distributed differently across the regions and two hypotheses concerning regional distribution on comorbidities were tested (Table 25). There were insufficient number of cases to test hypotheses concerning PTCA patients with diabetes.

Li: A smaller percentage of patients with previous myocardial infarction ($p<0.04$) from Other Rural Regions and a larger percentage were from the Western Region and Winnipeg and the hypothesis was rejected.

Lii: The proportions of patients with and without congestive heart failure ($p<.282$) were not significantly different across the three regions ($p<.282$) and the hypothesis could not be rejected.

Hypothesis M: Because health status is related to socioeconomic status, it was expected that patients from less affluent neighbourhoods would have more comorbidities. Two hypotheses were tested; there were insufficient numbers of PTCA patients with diabetes to test that hypothesis.

Mi: No differences in the distribution across income quintiles was found in patients with or without previous myocardial infarction ($p<.48$) and the hypothesis could not be rejected.

Mii: Proportionately more patients with congestive heart failure were from income quintile 1 while fewer were from quintiles 2-5 ($p<.009$) and the hypothesis was rejected.

Hypothesis N: Some comorbidities require stabilization prior to performing PTCA while other comorbidities do not. Two hypotheses were tested. Insufficient numbers of diabetic patients across waiting time were available for testing.

Ni: Fewer patients with previous myocardial infarction had index PTCA within 0-3 days of index angiography ($p < .001$) and the hypothesis was rejected.

Nii: More patients with congestive heart failure had PTCA within 0-30 days of index angiography ($p < .0001$) than patients without comorbidities and the hypothesis was rejected.

Waiting Time Between Index Angiography and Index PTCA

Waiting time is an important policy issue. Almost two-thirds (67.7%) of the patients had their PTCA within 30 days of their index angiography and almost eighty-seven percent had theirs within three months (Figure 8).

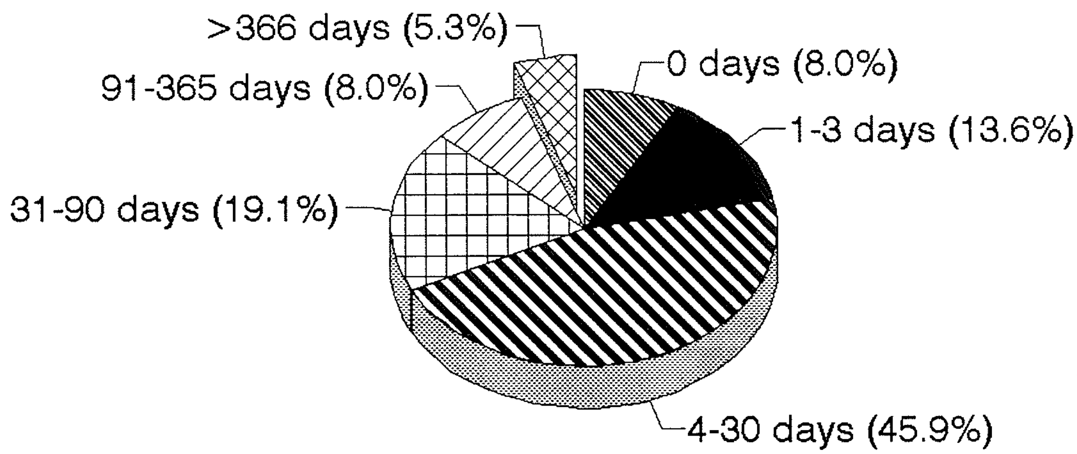

Figure 8. Time interval between index angiography and index PTCA

The mean waiting time between index angiography and index PTCA over the six years of the study was 79.9 days (SD ± 239.3 days, range = 0 to 2,140 days, mode = 0 days and median = 13 days). Since the distribution was skewed and because it was thought that patients who wait a year or more are clinically different than those who wait less than a year, the data was trimmed at one year. Trimming resulted in a loss of 108 PTCA patients and it was thought that these patients were treated medically, had repeat angiogram after a year and then were revascularized. Indeed 329 patients had a repeat angiogram after a year and 233 had PTCA while 14 had CABS and PTCA. Looking at the trimmed data, the mean waiting time between angiogram and PTCA was 30.4 days (SD ±48.3 days, median = 11 days, mode = 0 days and range = 0 to 353 days). Fifty percent of PTCA patients had their revascularization within 11 days of angiogram and 75% within 36 days.

The mean age of patients who waited over a year between index angiography and index PTCA was older than those who waited under a year (Table 26). More women had their PTCA within 0-30 days of their index angiography than men. No regional or income differences in waiting time were found.

Table 26

Comparison of Waiting Time by Sociodemographic Characteristics of Index PTCA Patients (FY 1987-1992)

	Waiting Time					
	0	1-3	4-30	31-90	91-365	>365
N	163	278	936	390	163	108
%	7.9	13.6	46.1	19.1	7.9	5.3
Age	60.5	60.7	60.6	59.3	58.7	62.8*
SD±	12.4	12.0	11.1	10.6	10.1	10.5
Men	113	194	645	282	136	70
%	7.8	13.5	44.8	19.6	9.4	4.9
Women	50	84	291	108	27	38*
%	8.4	14	48.7	18.1	4.5	6.3
Rural	28	52	197	106	33	22
%	6.4	11.9	45	24.2	7.5	5
Western	15	37	91	44	11	10
%	7.2	17.8	43.7	21.2	5.3	4.8
Winnipeg	120	189	648	240	119	76
%	8.6	13.6	46.6	17.2	8.5	5.5
Quintile 1	34	55	149	65	38	22
%	1.7	2.7	7.4	3.2	1.9	1.1
Quintile 2	27	51	187	79	23	26
%	1.3	2.5	9.3	3.9	1.1	1.3
Quintile 3	37	63	190	73	30	15
%	1.8	3.1	9.5	3.6	1.5	0.7
Quintile 4	38	49	189	87	40	19
%	1.9	2.4	9.4	4.3	2.0	0.9
Quintile 5	26	55	209	80	31	23
%	1.3	2.7	10.4	4.0	1.5	1.1

Note. $p<.01$.

Hypothesis O: Age was not expected to influence time between index angiography and index PTCA. An ANOVA identified that PTCA patients who waited over a year between index angiography and index PTCA were older than those who waited less than a year ($p < .02$).

Hypothesis P: While no gender differences in waiting time were anticipated, the study found that more women than men had an index PTCA within 0-30 days of an index angiography ($p < .005$) and so the hypothesis was rejected.

Hypothesis Q: Regional differences in waiting time were not expected and were not found ($p < .055$) and thus the hypothesis could not be rejected.

Hypothesis R: A prominent characteristic of national health insurance systems is that waiting time is based on severity, not ability to pay. No relationship was hypothesized between income and waiting time and none was found ($p < .382$).

Mortality

Having explored the differences in baseline characteristics of PTCA patients, and prior to examining the influence of these characteristics on survival, mortality was examined. The total number of patients who died after index PTCA (including repeat revascularization) was 152 (7.1%) and of these, 82 (53.9%) died within a year of the procedure. The 30 day mortality rate was 2.6%. Table 27 displays the number of patients who died after index PTCA.

Table 27

Patients Dying at Various Time Intervals After Index PTCA

Time Interval	Number	Percentage	Cumulative Number	Cumulative Percent
0 Days	13	8.6%	13	8.6%
1-3 Days	14	9.2%	27	17.8%
4-30 Days	18	11.8%	45	29.6%
31-90 Days	10	6.6%	55	36.2%
91-365 Days	27	17.8%	82	54.0%
>366 Days	70	46.0%	152	100.0%

Since the two procedures CABS and PTCA will be compared in the survival analyses in Chapter 5, the analyses will not be repeated here. For ease of reference, the results of the two survival models are displayed in Table 28.

Table 28

Comparison of Independent Predictors of Death After Index PTCA or CABS With and Without Comorbidities (0 days reference)

Model Covariate	Risk Ratio (95% Confidence Interval)	p Value
	No Comorbidities	
CABS	1.669 (1.295-2.149)	0.0001
Age 65-74	2.383 (1.810-3.138)	0.0001
Age 75+	3.100 (2.193-4.382)	0.0001
Time 1-3 days	0.611 (0.402-0.929)	0.0212
Time 4-30 days	0.542 (0.383-0.767)	0.0005
Time 31-90 days	0.381 (0.251-0.578)	0.0001
Time 91-365 days	0.387 (0.250-0.599)	0.0001
Income5*age75+	2.401 (1.057-5.455)	0.0363
	Comorbidities	
Age 65-74	2.142 (1.622-2.830)	0.0001
Age 75+	2.506 (1.759-3.570)	0.0001
1-3 Days	0.606 (0.394-0.930)	0.0220
4-30 Days	0.601 (0.421-0.860)	0.0053
31-90 Days	0.452 (0.294-0.693)	0.0003
91-365 Days	0.475 (0.303-0.743)	0.0011
Coagulopathies	2.543 (1.550-4.170)	0.0002
CHF	2.882 (2.250-3.692)	0.0001

Discussion

Sociodemographic Characteristics

Gender. Gender differences were found in all sociodemographic variables. Across the province, women were less likely than men to receive PTCA, just as they were less likely to receive angiography. Because gender differences in the prevalence of IHD are age-related, it is unlikely that these gender differences in referral patterns indicate that men have more appropriate indicators for PTCA, although this cannot be determined from the database because the results of angiography are not available in the database. The most probable reason for the lower utilization of PTCA in women is the fact that a smaller proportion of women were referred for angiography and consequently a smaller proportion were available for, and received, the therapeutic procedures.

Women who had PTCA were distinctly different than men on all sociodemographic parameters. The fact that women were, on average, six years older than men at PTCA reflects the protective effect of estrogen on the incidence of CAD in pre-menopausal women. A shift in gender utilization with age occurred and corresponds to that reported in the literature; younger men were 2.7 times as likely to have PTCA, but by age 65 proportionately more women had PTCA. The gender of PTCA patients was found to vary by region of residence as a larger percentage of women and a smaller percentage of men who resided in Winnipeg had PTCA. It is possible that rural women declined PTCA more often than their Winnipeg counterparts, however it is more likely that they were not being referred for angiography and PTCA as often. It is not known whether this difference represents underutilization outside Winnipeg or overutilization within Winnipeg. To answer the question "Which rate is the right rate?" an appropriateness study would be required. What can be stated from the results of this study is that neither gender, region nor a region-gender interaction was predictive of increased mortality. The gender of PTCA patients was also found to vary by income quintile as a larger percentage of women from the lower income quintiles had PTCA than men, while a larger percentage of men from the upper income quintiles had PTCA than women. Since the literature reports an inverse relationship between income and CAD, the finding that a larger percentage of men from the highest income quintiles had PTCA is atypical and will be addressed later.

In the literature, higher mortality rates in women were initially attributed to differences in baseline characteristics. While this increased mortality was initially thought to be related to smaller body size and smaller coronary arteries, (Cowley, Mullin, Kelsey, Kent, Gruenitz, Detre, & Passamani, 1985) improved procedural techniques and use of analytical techniques in which age, body surface area and severity of disease are controlled for, has eliminated gender differences in PTCA mortality (Arnold, Mick, Piedmonte & Simpfendorfer, 1994). Survival curves confirmed that gender affected survival; when gender was the single variable controlled for, women had a lower probability of survival for both CABS and PTCA. When all covariates were entered into the survival model, gender was not predictive of decreased probability of survival. Thus, while there were significant differences in all sociodemographic characteristics of women, the effects of gender disappeared when other variables were controlled for and gender did not predict differential probability of survival. Without indications of the severity of CAD (not available in this database) gender referral bias cannot be confirmed or ruled out.

Age. As expected there was a strong age effect on utilization of, and outcomes associated with, PTCA. Age-related utilization of PTCA reflects the natural history of CAD; younger men were more than twice as likely as women to have PTCA after angiography, but by age 65 and over, the percentage of women having PTCA was greater than men. On average women were six years older than men at PTCA. No differences in the mean age of patients across regions or income quintiles were found. Thus age differences were found in only one of the baseline sociodemographic variables, gender.

In the literature, higher mortality rates have been attributed to differences in baseline characteristics and while significant age differences were found only in gender, age was an important independent predictor of death. Survival curves confirmed that age affected survival. When age was the single variable controlled for, those 75 years of age and over had the lowest probability of survival for PTCA and CABS, followed by those 65-74 years of age. Patients 25-64 had the highest probability of survival for PTCA, followed by CABS. When all covariates but comorbidities were entered into the survival model, age 65 and over conferred an elevated risk ratio of 2.4. Only one other variable conferred a similarly elevated risk ratio, an interaction between age 75 plus and income quintile 5. However this interaction term disappeared when comorbidities were entered into the model, while the age effect did not.

In the model with comorbidities, the effect of the procedure also disappeared. In the model with comorbidities, age 65 and over continued to confer an elevated and only slightly decreased risk ratio, 2.1. To summarize, age is an independent predictor of decreased survival in both PTCA and CABS. Patients 65 years of age and over have over twice the risk ratio of younger patients, irrespective of which procedure they have. Yet utilization of PTCA increased by 10% in the elderly during the course of the study and patients 65 years of age and over constituted 44% of the PTCA population in 1992 in Manitoba. In spite of the fact that randomized control trials on the efficacy of PTCA in the elderly have not been concluded, Manitoba joins other jurisdictions in increased utilization of the procedure in the elderly.

Region of Residence. In a province in which cardiac services are centralized in the two teaching hospitals in Winnipeg, access to these services from outside Winnipeg is critical. This study found that patients from Other Rural Regions and the Western Region had less access to PTCA than patients from Winnipeg. A regional referral bias existed that reflected the utilization pattern of angiography. While PTCA is a relatively recent technology, these findings of a funnel effect from screening procedure to therapeutic procedure do not support a new technology diffusion hypothesis.

As already reported, regional differences in gender existed with a larger percentage of women and a smaller percentage of men from Winnipeg having PTCA than from the other regions. This finding likely represents a funnel effect in that a larger percentage of women and a smaller percentage of men from Winnipeg also had angiography. Again, because angiography serves as a screening procedure for CABS and PTCA, it is understandable that this funnel effect would occur. This regional referral bias may indicate different selection criteria in referral of the women for angiography in the regions outside Winnipeg. No regional age differences were found.

However, regional differences in the income distribution of PTCA patients existed and this finding generates serious concern. Outside Winnipeg, the distribution of income reflected the relationship between CAD and socioeconomic status reported in the literature, that is poorer citizens have increased incidence of CAD and thus increased utilization of PTCA would be expected. However the finding that, within Winnipeg, patients from wealthier neighbourhoods had increased utilization of PTCA contradicts the literature and may indicate increased patient demand. If Winnipeg patients from wealthier neighbourhoods have less severe CAD but were less willing to tolerate angina symptoms, are better informed about treatment options and are requesting PTCA, two fundamental questions remain to be addressed. The first question is whether patients from poorer neighbourhoods within Winnipeg were being denied access to PTCA. If finite resources are maldistributed because of differential access, this would be a serious concern. Conversely, if patients from poorer neighbourhoods within Winnipeg were found not to be denied access, this may indicate excess resource capacity. Only a waiting list which also includes information about SES could directly address this question. The second question is whether the indications for PTCA in the Winnipeg wealthy are appropriate. Appropriateness of PTCA cannot be answered with the data available. Because region of residence was not a predictor of survival when all covariates were controlled for, Winnipeg residents, rich or poor, do not seem to be disadvantaged.

Income. No differences in the distribution of PTCA patients across income quintiles from that of the general population were found. This finding appears to be supportive supportive of national health insurance because it apparently demonstrates that ability to pay does not effect utilization. However, the literature indicated that poorer patients have increased incidence of CAD and thus one would have expected increased utilization in the poor.

As noted above, a gender differential was found in income distribution with a larger percentage of women from poorer neighbourhoods and men from wealthier neighbourhoods receiving PTCA. The gender differential is in the direction expected for women. But the increased utilization of PTCA in men from wealthier neighbourhoods is a concern. Further, the results indicate that a gender income/utilization gradient occurred, for as income increased so did utilization in men. One interpretation for this finding is that an increased demand associated with higher education and higher income may be operating. Other reasons for the finding may be that higher income may be associated with more self-employment. An urgency in returning to work due to limited sickness and disability plans and difficulty in obtaining replacement personnel may exist; physicians may elicit this information and may refer these patients more frequently. While income may serve as a proxy for other clinical variables not available in administrative databases, a complex mixture of increased patient demand and physician referral is hypothesized as explanations for the income/utilization gradient in men.

The mean age of patients did not vary with income. The regional variation in income, in which a larger percentage of Winnipeg patients were from the highest income quintile, has already been addressed. In spite of baseline differences in income across gender and region, income was not an independent predictor of differential survival. An interaction between the highest income quintile and the elderly disappeared when comorbidities were entered into the model and it is thought that the interaction may have been spurious.

Clinical Characteristics

Comorbidities. Patients with comorbid disease may have decreased probability of survival after therapeutic procedures and so describing and adjusting for comorbid disease is important. As identified in Chapter 2, the Luft and Romano comorbidities which were originally designed specifically for investigation of CABS outcomes were used in this study. The diagnosis, previous myocardial infarction, was added to the comorbidities in order to test its predictive capability. The MCHPE database currently lacks a severity scoring system and comorbidities are the only modifier of diagnoses currently available to the researcher.

Only three comorbidities occurred in at least 1% of the cases: (a) diabetes (1.3%, n = 27), (b) congestive heart failure (5.6%, n = 120), and (c) previous myocardial infarction (10%, n = 213). It should be recalled that the comorbidity, peripheral vascular disease, had been deleted because it was found to be collinear with hypertension and major vascular surgery. While PTCA patients had three of the same comorbidities as CABS patients, coagulopathies was the fourth and additional comorbidity in CABS patients. It is not known whether the infrequent occurrence of comorbidities was due to poor recording practices or narrow selection processes.

Baseline differences in the distribution of comorbidities were found. While no differences in the mean age of diabetic and previous myocardial infarction patients were found, patients with CHF were older than patients without this comorbidity. Gender differences in the incidence of these comorbidities occurred. Diabetes and CHF, were more prevalent in women while previous myocardial infarction was more prevalent in men. The latter reflects the different IHD presentation of women and their lower AMI rates which were reviewed in Chapter 1. Regional differences were found only in the distribution of previous myocardial infarction patients and may reflect the fact that the Western Region and Winnipeg have different selection/referral criteria for PTCA. An income differential was also found as more patients from less affluent neighbourhoods had CHF. CHF patients were also more likely to have their PTCA within 0-30 days of their index angiography. Previous AMI patients were less likely to have their PTCA within 0-3 days of their index angiography and more likely to have it between 31-365 days. The rationale for this differential waiting cannot be understood without knowing the extent of CAD in patients with these comorbidities.

The survival analyses identified the impact of comorbidities on the prognosis of PTCA patients. In the model without comorbidities, patients with CABS had a decreased probability of survival. But when comorbidities were entered into the model, CABS patients did not differ from PTCA patients in their risk of survival. Rather, patients who underwent either procedure had an elevated risk of mortality if they had coagulopathy (RR=2.543) or CHF (RR = 2.882). Since coagulopathies occurred infrequently in PTCA patients (n = 4), congestive heart failure emerges as the primary comorbidity for

PTCA patients in this database. In the model without comorbidities, patients from wealthy neighbourhoods who were 75 years of age and over had a 2.401 increased risk of mortality. Again when comorbidities were entered into the model, this interaction effect disappeared.

Only age conferred as great an increased risk of mortality as the comorbidities, coagulopathies and congestive heart failure. These findings are in keeping with the literature (Leape et al., 1991); additional comorbidities such as diabetes have been found in other studies to confer elevated risk ratios but they occurred or were recorded too infrequently in this population.

Time interval between index Angiography and index PTCA. From a policy perspective, an important finding was the fact that two-thirds of patients had their PTCA within 30 days of index angiography. Indeed, 86.6% of the population had their PTCA within 90 days. Quantifying waiting time and examining its impact upon survival was a unique contribution of this study. Gender differences in waiting time were found; women waited less time than men between index angiography and index PTCA. More women had PTCA within 0-30 days or after 365 days than men. The fact that women waited less time than men suggests that women had more severe CAD. Patients who waited more than 365 days between index angiography and index PTCA were older than those who had the procedure at any other time interval. It is likely that patients who waited more than 365 days were treated medically, because they all had a repeat angiography prior to the PTCA. The passage of time between the index angiography and index PTCA likely is responsible for the modest age difference.

Waiting time was sensitive to the one indicator of clinical condition available in the database: comorbidity. As mentioned previously, the type of comorbidity was reflected in the time interval between diagnostic and therapeutic procedure. Patients with CHF were more likely to have their procedure within 0-3 days of their index angiography while patients with previous myocardial infarction were more likely to wait 31-365 days. Waiting time can also be viewed as a proxy for equity in a national health insurance system. No region of residence nor income differences were found in the time that patients waited between index angiography and index PTCA. Discrimination on the basis of region or income did not occur under the national health care system as it operated in Manitoba during this study.

The impact of waiting time on survival was a unique dimension of the study. Analysis confirmed that waiting time affected survival; when 30 day wait between index angiography and index PTCA was the single variable controlled for in the survival curves, patients who waited 0 days had the lowest probability of survival. As waiting time increased, survival following the procedure increased, although in each time interval CABS patients had decreased probability of survival.

When waiting time was entered into the model without comorbidities, two time intervals had decreased risk ratios: (a) 1-30 days (0.611), and (b) 31-365 days (0.381). When waiting time was entered into the model with comorbidities, patients who waited 1-365 days between index angiography and index PTCA had a risk ratio of 0.606. Even after adjusting for comorbidities, not having index PTCA on the same day as index angiography increased the probability of survival by nearly 40%. Clearly, patients who had the procedures on the same day were at increased risk.

Since no other study has examined the effect of waiting time on survival, qualitative statements about the length of the waiting time have no benchmark; rather this study establishes a benchmark against which future studies can be compared. Clearly, patients who have PTCA or CABS on the same day as index angiography are seriously ill; waiting time may serve as a proxy for CAD severity in administrative databases. Only one critical waiting time period emerged from this study: 0 days wait. After adjusting for covariates, patients who waited more than one day had a 40% increase in the probability of survival. However, this data did not find that waiting 1 day or 364 days affected survival. This data confirms physicians' ability to prioritize patients. What the data cannot do is to identify those patients who had angiography, needed a PTCA or CABS and died while awaiting the procedure: only a centralized waiting list can identify those patients. It is important to distinguish between those who died while awaiting PTCA or CABS from those who died after receiving PTCA or CABS.

CHAPTER 5

Coronary Artery Bypass Graft Surgery

Introduction

A previous study of coronary artery bypass surgery (CABS) in Manitoba from 1980-1984 identified minimal growth in utilization for patients aged 25-44 years, a doubling for males aged 45-74 and for females aged 55-74 and marked growth in the elderly (Roos & Sharp, 1989). These time trends mirror those occurring in other Canadian jurisdictions but are lower than in the U.S. (Peters et al., 1990; Nair et al., 1992; Anderson et al., 1993). In 1985 PTCA was introduced in Manitoba. PTCA was originally viewed as a replacement for single vessel CABS, but the literature soon reported that it had become complimentary to multi-vessel CABS. This study analyzed sociodemographic and clinical data available in the Manitoba Centre for Health Policy and Evaluation (MCHPE) database to examine utilization of, and outcomes associated with, CAD procedures. Age was an important variable, since the incidence of CAD is age-related and shifts to increased utilization of coronary surgical procedures in the elderly have been reported (Roos & Sharp, 1989; Anderson et al., 1993). Gender was also investigated because CAD is delayed in women and women have also been reported to experience lower utilization of CAD procedures and more adverse outcomes. Regional variation in utilization was examined because variation in CABS among nations (Nair et al., 1990), within Canada (Peters, Changani, Paddon & Nair, 1990) and within Manitoba (Roos & Sharp, 1989) had been noted. Thus region of residence is an important variable to examine in a province in which CABS is centralized in Winnipeg.

Because the incidence of CAD is related to socioeconomic status, Statistics Canada's census data on household income at the enumeration area was also examined. Administrative data lack much of the clinical data associated with primary data collection, such as severity of CAD, but two important clinical variables were available and examined. Pre-existing comorbid disease can lead to differential outcomes and the Luft and Romano (1993) comorbidity index developed for CABS was used. A unique feature of this study was the quantification of waiting time between index angiography and index CABS or PTCA. Countries with national health insurance are often purported to have increased waiting time for access to services, but to date objective data has been lacking to substantiate or refute this claim.

Hypotheses

The purpose of this chapter was to determine: (a) whether the baseline characteristics of index CABS patients who met the study inclusion criteria vary, and (b) if these characteristics predicted survival. The inclusion criteria were patients who: (a) were 25 years of age and older, (b) were residents of Manitoba, and (c) had an index angiography in Manitoba between fiscal year 1987 and 1992. Patients who met the inclusion criteria were followed from FY 1987 to 1992 to determine whether they subsequently had an index PTCA and/or and index CABS. This chapter reports on the patients who had an index CABS.

Two types of baseline characteristics were examined: (a) sociodemographic, and (b) clinical characteristics. As displayed in Table 29, the hypotheses related to sociodemographic characteristics were:

(a) there are no differences in the number of men and women who had CABS,

(b) there are no differences in the mean ages of men and women who had CABS,

(c) there are no differences in the region of residence of men and women who had CABS,

(d) there are no differences in the income quintiles of men and women who had CABS,

(e) there are no differences in the number of patients in each region who have CABS,

(f) there are no regional differences in the mean ages of CABS patients,

(g) there are no regional differences in the income quintiles of CABS patients,

(h) there are no differences in the number of patients in each income quintile who have CABS, and

(i) there are no differences across income quintiles in the mean ages of CABS patients.

Table 29

Hypotheses Related to Baseline Sociodemographic Characteristics of Index CABS Patients

Variables	Gender (A)	Region (E)	Income (H)
	Age (B)		
	Region (C)	Age (F)	
	Income (D)	Income (G)	Age (I)

Table 30 displays the hypotheses concerning the relationship of the clinical variables, comorbidities and waiting time, to sociodemographic characteristics. The hypotheses are:

(j) there are no differences in the mean ages of CABS patients who have comorbidities,

(k) there are no gender differences in comorbidities in CABS patients,

(l) there are no regional differences in the comorbidities of CABS patients,

(m) there are no differences across income quintiles in the comorbidities of CABS patients,

(n) there are no differences in the comorbidities of CABS patients by time interval between index angiography and index CABS,

(o) there are no differences in the mean ages of CABS patients by time interval between index angiography and index CABS,

(p) there are no differences in the time interval between index angiography and index CABS of men and women,

(q) there are no regional differences in the time interval between index angiography and index CABS of CABS patients, and

(r) there are no differences across income quintiles in the time interval between index angiography and index CABS of CABS patients.

Table 30

Hypotheses Related to Baseline Clinical Characteristics of Index CABS Patients

	Clinical Variables	
Sociodemographic Variables	Comorbidities	Time
	Age (J)	
	Gender (K)	Age (O)
	Region (L)	Gender (P)
	Income (M)	Region (Q)
	Time (N)	Income (R)

Finally, the impact of both the sociodemographic and clinical characteristics on survival was hypothesized:

(s) there are no differences in the survival of CABS and PTCA patients,

(t) there are no gender differences in the survival of CABS and PTCA patients,

(u) there are no age differences in the survival of CABS and PTCA patients,

(v) there are no differences in the survival of CABS and PTCA patients adjusting for waiting time, and

(w) there are no differences in the survival of CABS and PTCA patients adjusting for gender, mean age, region of residence, income quintiles, comorbidities or time between index angiography and index CABS or PTCA.

Analysis

Baseline data are presented as mean ± 1 SD for continuous data and counts for discrete data. Comparisons of characteristics between genders was performed using Student's t test for continuous variables and x^2 for discrete variables ($p < .05$, two-tailed). To compare characteristics among regions, income quintiles and waiting time, ANOVA was used for continuous variables and x^2 for discrete variables. In making pairwise comparisons following significant ANOVA results, the Tukey method was used to control the family-wise error rate at 0.05. Only those comorbidities with sufficient cell sizes for chi-square testing are displayed.

Collinearity

Prior to conducting the survival analyses, correlation coefficients were obtained for the 25 dichotomized explanatory variables in order to assess collinearity. Because a positive correlation coefficient was found between two comorbidities: (a) peripheral vascular disease and hypertension ($r=0.1055$), and (b) peripheral vascular disease and major vascular surgery ($r=0.2807$), peripheral vascular disease was deleted from the models.

Survival Curves

Survival time from CABS and PTCA was the dependent variable of interest. Kaplan Meier survival curves were calculated using the SAS program LIFETEST. Unadjusted survival curves were generated for PTCA and CABS patients to determine if the probability of survival differed between the two groups. Bivariate analyses were also performed on the survival curves for PTCA and CABS patients; gender, age and 30 day waiting time were examined. The log-rank statistic and p values were calculated to test for the homogeneity of survival curves between the two treatment groups and the association of failure time with the covariates, age, gender and 30 day waiting time.

Survival Model Adequacy

Cox proportional hazard multivariate regression was conducted using the SAS program PHREG. In order to assess the model fit, the likelihood ratio test was used. Maximum likelihood estimates were examined using the -2 Log Likelihood statistic. A lower -2 log likelihood estimate is indicative of a better fit; the -2 log likelihood statistic has a chi-square distribution under the null hypothesis that all the explanatory variables in the model are 0. The chi-square statistic was examined to assess the fit of the model with and without covariates. The model with the lowest p values constituted the best fit.

Results

Sociodemographic and Clinical Characteristics

Overview

There were 2,699 (25.2%) patients who had an index bypass following an index angiography and of these, ten (0.37%) patients went on to have a repeat bypass during the six years of the study. The majority of CABS patients (74.2%) were men while one quarter (25.8%) were women. Baseline gender differences were found in all sociodemographic variables; women were older than men and a larger percentage of women were poorer and more likely to live in Winnipeg. Up to age 75, utilization of CABS increased with age in both men and women. The majority of CABS patients were from Winnipeg and proportionately more patients were referred for CABS who resided in Winnipeg than in Other Rural Regions and the Western Region than would have been expected from the regional population distribution. Regional differences in age and income were found. There were fewer CABS patients than expected from quintiles 1, 4 and 5 and more from quintiles 2 and 3 based on the regional distribution of income quintiles. Differences in the mean age of CABS patients across income quintiles existed. Of the fifteen possible comorbidities, nine were recorded in more than 1% of the CABS patients. Baseline differences in sociodemographic variables of patients with comorbidities were found, but no simple pattern emerged. Almost half (47.6%) of the patients had their index CABS within 30 days of their index angiography while nearly two-thirds (65.4%) had theirs within 90 days. Differences in waiting time by age, gender, region and comorbidities existed; no waiting time differences were attributable to income.

Gender

Gender differences were found in all pre-procedural baseline sociodemographic variables (Table 31). Fewer women than men had CABS; a larger percentage of women were older, poorer and more likely to reside in Winnipeg than men.

Table 31

Baseline Sociodemographic Characteristics of Index CABS Patients by Gender

	Male	Female
Number	2,009 (74.2%)	698 (25.8%)**
Age (SD±)	62.9 (9.4)	66.2 (8.7)**
Region of Residence		
Other Rural (%)	490 (24.4%)	136 (19.7%)
Western (%)	249 (12.4%)	73 (10.6%)
Winnipeg (%)	1,270 (63.2%)	481 (69.7%)+
Income Quintile		
Quintile 1 (%)	299 (15%)	145 (21.2%)
Quintile 2 (%)	442 (22.3%)	150 (22%)
Quintile 3 (%)	439 (22.1%)	153 (22.4%)
Quintile 4 (%)	378 (19%)	135 (19.8%)
Quintile 5 (%)	430 (21.6%)	100 (14.6%)*

Note. *$p < .0001$. **$p < .001$. +$p < .01$.

Hypothesis A: While the literature identified that a larger proportion of men than women have CABS, the null hypothesis tested that there would be no differences in the number of men and women who had CABS. Almost three-quarters (74.2%) of the patients were men and 25.8% were women ($p < .001$) and the hypothesis was rejected (Table 31). This male: female ratio remained constant over the six years of the study. Patients were more likely to have CABS than PTCA after index angiography ($p < .00001$).

Hypothesis B: Since CAD occurs earlier in men than in women it was expected that men would be younger than women at index CABS. The null hypothesis tested that CABS men and women would be the same age, however it was found that women were more than three (3.2) years older than men ($p < .001$) and the hypothesis was rejected. Overall, the mean age at index CABS was 63.8 years (SD ± 9.3). For men, the mean age was 62.9 years (SD ± 9.4, range = 31 to 85) while for women the mean age was 66.1 years (SD ± 8.7, range = 31 to 87).

Percentage of index CABS patients by age and gender. Men had a greater probability of proceeding from index angiography to index CABS than women ($p < .00001$). When age was factored in (omitting the age group 25-35 in which there were few cases), the highest percentage of index CABS occurred in both men (38.6%) and women (47.4%) aged 65-74 years (Table 32). At age 35-44, men were more than two and a half (2.6) times more likely than women to have CABS. This male: female difference narrowed with each successive decade until by age 65-74, men were 0.61 less likely than women to proceed to CABS. As age increased there was a steady increase in the percentage of both men and women having CABS, until age 75 and over, when the percentage in both sexes declined.

Table 32

Percentage of Index CABS by Age Group and Gender

	Age groups					
	25-34	35-44	45-54	55-64	65-74	75+
(n=2,699)						
Male %	0.3	3.6	13.9	33.9	38.6	9.7
N	7	72	277	682	776	195
Female %	0.6	1.4	7.8	27.0	47.4	15.8
N	4	10	54	186	327	109

Note. n = 2,699

Trends over time in utilization of CABS by age. Between 1987 and 1992, the relative utilization of CABS decreased by 11.4% in the under 65 year age group (from 52.4% of all CABS in 1987 to 41% in 1992), increased by 4.4% in those 65-74 and increased by 7% in those over 75 (Figure 9). The year 1990 marked the shift in utilization patterns when more index CABS were performed in the elderly than in the young.

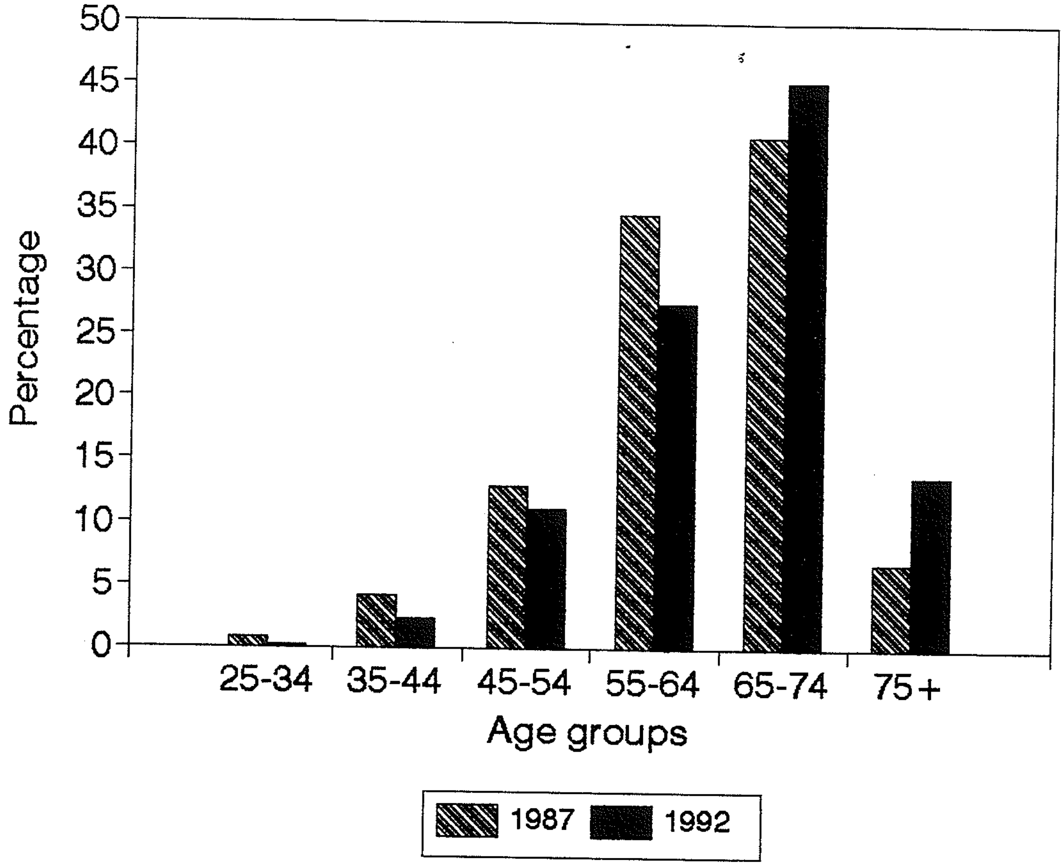

Figure 9. Age distribution difference in index CABS between FY 1987 & 1992

Hypothesis C: While no gender differences in the region of residence were anticipated, a larger percentage of women than men referred for CABS resided in Winnipeg ($p < .01$) and the hypothesis was rejected (Table 31).

Hypothesis D: Because of national health insurance, income was not assumed to have a bearing on whether or not men and women had CABS, however significant gender differences in the highest and lowest income quintiles were found (Table 31). A larger percentage of women than men were from the lowest quintile while a larger percentage of men than women were from the highest quintile and the hypothesis was rejected ($p < .0001$). Figure 10 shows that wowmen from the highest income quintile have lower utilization men and women in the upper and lower quintiles had different CABS utilization patterns.

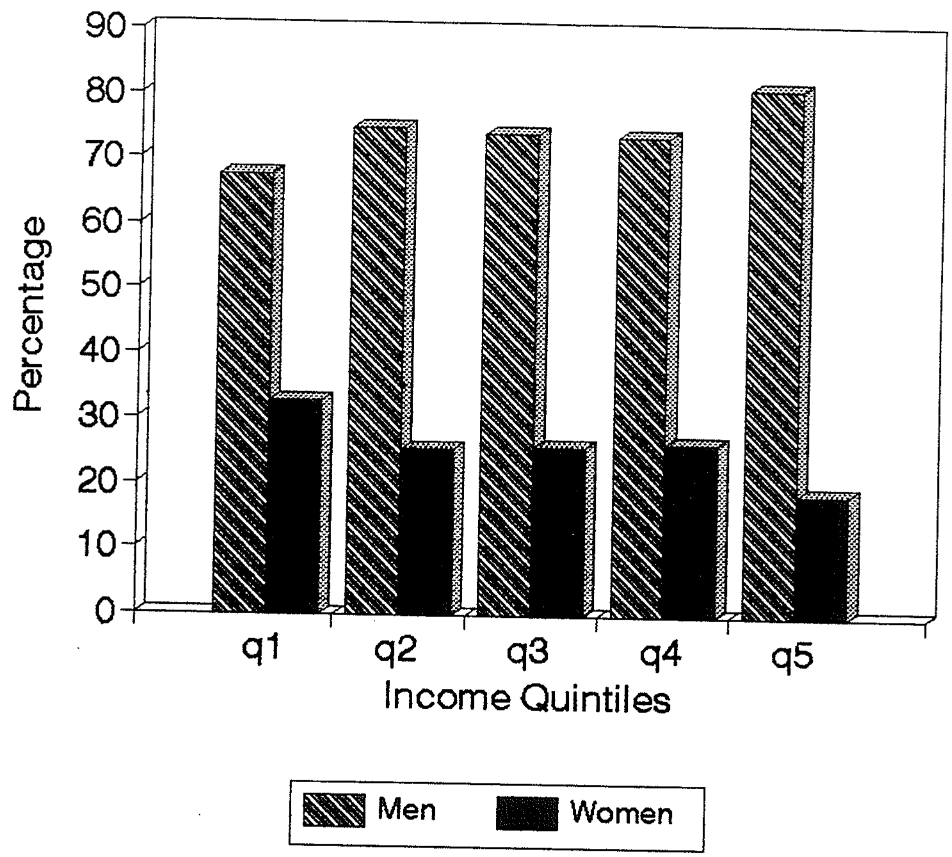

Figure 10. Index CABS income quintile distribution by gender (FY 1987-1992)

Region of Residence

Centralization of both CAD diagnostic and therapeutic procedures and physician specialists in Winnipeg could lead to differential regional utilization. Regional differences in the numbers of CABS patients were found with more patients from Winnipeg and fewer from Other Rural Regions and the Western Region (Table 33). Also a larger percentage of the Winnipeg patients were women (Table 31). Regional differences existed on all other sociodemographic variables. Patients from Other Rural Regions were younger than patients from the Western Region and Winnipeg (Table 33). Regional differences in the highest and lowest income quintiles were found.

Table 33

Baseline Sociodemographic Characteristics of Index CABS Patients, by Region

	Region		
	Other Rural	Western	Winnipeg
Number (%)	626 (23.2%)	322 (11.9%)	1,751 (64.9%)*
Age (SD±)	62.8 (9.5)+	64.2 (9.7)	64.1 (9.2)
Quintile 1 (%)	137 (22.1%)	92 (28.9%)	214 (12.4%
Quintile 2 (%)	176 (28.3%)	136 (42.2%)	282 (16.3%)
Quintile 3 (%)	175 (28.2%)	52 (16.2%)	365 (21.1%)
Quintile 4 (%)	103 (16.6%)	30 (9.3%)	380 (21.9%)
Quintile 5 (%)	30 (4.8%)	11 (3.4%)	489 (28.3%)**

Note. *$p < .0001$. **$p < .001$. +$p < .02$.

<u>Hypothesis E:</u> The majority (58.5%) of Manitoba residents age 25 and over, live in the Winnipeg Region, followed by the Other Rural Region (26.6%) and the Western Region (14.8%) and it was expected that utilization of CABS would reflect this regional population distribution. The null hypothesis tested that there were no differences in the number of CABS patients from each region. In comparison to the population distribution of adults 25 years of age and over, proportionately fewer patients had CABS from Other Rural Regions and the Western Region and more from the Winnipeg Region ($p < .0001$) and the hypothesis was rejected.

<u>Hypothesis F:</u> CABS patients were not expected to vary in age by region of residence. However, patients from Other Rural Regions were younger than patients from the other two regions ($p < .02$) and the hypothesis was rejected.

<u>Hypothesis G:</u> Regional differences in income distribution were not anticipated. Figure 11 displays that in Other Rural Regions and the Western Region, the smallest percentage of patients came from the highest income quintile. In Winnipeg the smallest percentage of patients came from the lowest income quintile and the largest percentage came from the highest income quintile ($p < .0001$) and the hypothesis was rejected.

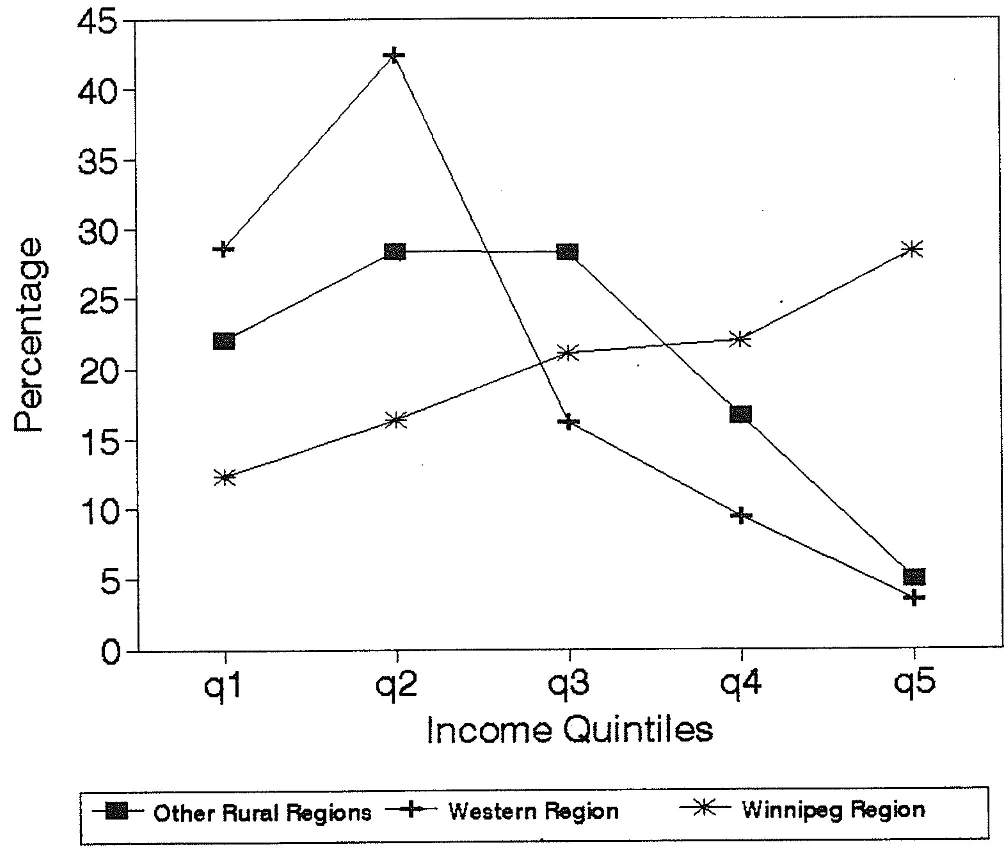

Figure 11. Index CABS income quintile distribution by region (FY 1987-1992)

Income

The income distribution of CABS patients differed from the general population aged 25 and over (Table 34). Gender differences in income of CABS patients has previously been reported (Table 31). CABS patients differed in age across income quintiles (Table 34). Similarly, regional disparities in income have already been identified with the smallest percentage of income quintile 1 patients residing outside of Winnipeg and the largest percentage of income quintile 5 patients residing in Winnipeg (Table 33).

Table 34

Sociodemographic Characteristics of Index CABS Patients, by Income Quintile (FY 1987/88-1992/93)

	Income Quintile				
	1	2	3	4	5
Number	444	593**	592**	513	530
%	16.6	22.2	22.2	19.2	19.8
Age	63.8	64.5	65.0	63.1	62.1*
Sd±	9.8	9.1	8.9	9.4	9.3

Note. *$p < .0001$. **$p < .001$.

Hypothesis H: Current literature indicates that an inverse relationship between CAD and socioeconomic status exists, and a larger percentage of CABS patients were expected to come from the lower income quintiles. By definition, quintile construction places 20% of the population into each quintile. The hypothesis tested that there would be no differences in the percentage of CABS patients in each quintile. A smaller percentage of patients from quintiles 1, 4 and 5 and a larger percentage from quintiles 2 and 3 were found and the hypothesis was rejected ($p < .001$).

Hypothesis I: The mean age of CABS patients was not expected to vary by income quintile. An ANOVA identified that patients from quintile 5 were significantly younger than those in the other quintiles ($p < .0001$) and the hypothesis was rejected.

Comorbidities

While nine comorbidities occurred in at least 1% of CABS patients, only four comorbidities occurred in sufficient numbers to be able to conduct chi-square tests: (a) previous myocardial infarction (21.9%, n = 590), (b) congestive heart failure (14.5%, n = 391), (c) coagulopathy (3.7%, n = 101), and (d) diabetes (2.4%, n = 65). Baseline differences in some of these comorbidities across sociodemographic characteristics were found but no simple pattern emerged.

Hypothesis J: It was anticipated that the mean age of CABS patients with comorbidities would be the same as those without comorbidities and four hypotheses were tested (Table 35).

Ji: No difference in the mean age of patients with or without diabetes ($p < .24$) was found and the hypothesis could not be rejected.

Jii: Patients with coagulopathies were significantly older than patients without comorbidities ($p < .001$) and the hypothesis was rejected.

Jiii: Patients with congestive heart failure were older than patients without comorbidities ($p < .0001$) and the hypothesis was rejected.

Jiv: Patients who had a previous myocardial infarction were younger ($p < .0003$) than patients without this comorbidity and the hypothesis was rejected.

Table 35

Comparison of Comorbidities by Sociodemographic Characteristics of Index CABS Patients (FY 1987/88-1992/93)

	Comorbidities			
	Old AMI (n = 590)	CHF (n = 391)	Coagulopathy (n = 101)	Diabetes (n = 65)
Age (SD±)	62.6 (9.6)**	67.9 (8.4)*	67 (8.2)**	62.4 (10.1)
Men (%)	478 (81%)	236 (60%)	71 (70%)	41 (63%)
Women (%)	112 (19%)*	155 (40%)*	30 (30%)	24 (37%)+
Other Rural (%)	108 (18%)	96 (25%)	24 (24%)	17 (26%)
Western (%)	69 (12%)	47 (12%)	11 (11%)	5 (8%)
Winnipeg (%)	413 (70%)+	248 (63%)	66 (65%)	43 (66%)
Quintile 1 (%)	79 (14%)	86 (22%)	11 (11%)	14 (21%)
Quintile 2 (%)	122 (21%)	93 (24%)	24 (25%)	18 (28%)
Quintile 3 (%)	143 (24%)	80 (21%)	21 (22%)	18 (28%)
Quintile 4 (%)	120 (20%)	72 (18%)	16 (16%)	11 (17%)
Quintile 5 (%)	122 (21%)	58 (15%)+	25 (26%)++	4 (6%)
O Days (%)	4 (1%)	14 (4%)	3 (3%)	1 (2%)
1-3 Days (%)	39 (8%)	64 (19%)	15 (15%)	5 (8%)
4-30 Days (%)	185 (35%)	159 (46%)	27 (27%)	27 (42%)
31-90 Days (%)	118 (23%)	58 (17%)	13 (13%)	12 (19%)
91-365 Days (%)	171 (33%)	49 (14%)	27 (27%)	13 (20%)
365+ Days (%)	66 (11%)*	38 (10%)*	16 (16%)	6 (9%)

Note. *$p < .00001$. **$p < .001$. +$p < .01$. ++$p < .05$.

Hypothesis K: While gender differences in CABS patients with and without comorbidities were not expected, hypotheses concerning gender differences in four comorbidities were tested (Table 35).

Ki: When the gender hypothesis concerning diabetes was tested, CABS patients with diabetes, as opposed to those without diabetes, were more likely to be female ($p < .003$) and the hypothesis was rejected.

Kii: No difference in the percentage of men and women with or without coagulopathies was found ($p < .3$) and the hypothesis could not be rejected.

Kiii: CABS patients with CHF were more likely to be female than other CABS patients ($p < .0001$) and the hypothesis was rejected.

Kiv: On the other hand, CABS patients with a previous myocardial infarction were more likely to be male ($p < .0001$) and the hypothesis was rejected.

Hypothesis L: It was assumed that CABS patients with comorbidities would not be distributed differently across the regions than those without comorbidities and four hypotheses were tested (Table 35).

Li: No regional differences in the distribution of patients with and without diabetes were detected and the hypothesis could not be rejected ($p < .53$).

Lii: No regional differences in the distribution of patients with coagulopathies ($p < .94$) was found and the hypothesis could not be rejected.

Liii: Regional differences in the distribution of congestive heart failure were not found ($p < .77$) and the hypothesis could not be rejected.

Liv: A larger percentage of patients with previous myocardial infarction were from Winnipeg while a smaller percentage were from Other Rural Regions ($p < .004$) and the hypothesis was rejected.

Hypothesis M: It was postulated that CABS patients with comorbidities would not differ from those without comorbidities across income quintiles and four hypotheses were tested (Table 35).

Mi: No differences in the distribution across income quintiles for CABS patients with diabetes ($p < .07$) were found and the hypothesis could not be rejected.

Mii: A larger proportion of patients with coagulopathies came from quintiles 2 and 5 while fewer came from quintiles 1, 3 and 4 ($p < .02$) and the hypothesis was rejected.

Miii: A larger percentage of patients with congestive heart failure came from quintiles 1 and 2 and a smaller percentage came from quintiles 3, 4, and 5 ($p < .006$) and the hypothesis was rejected.

Miv: No differences in the distribution across income quintiles for patients who had a previous myocardial infarction ($p < .13$) occurred and the hypothesis could not be rejected.

Hypothesis N: While it was anticipated that patients with comorbidities would have shorter waiting times between index angiography and index CABS, four hypotheses tested that there would be no differences in waiting times for four comorbidities.

Ni: No differences in waiting times were found for patients with diabetes as opposed to those without comorbidities ($p < .871$) and the hypothesis could not be rejected.

Nii: Patients with coagulopathies experienced no difference in waiting time than those with no comorbidities ($p < .069$) and the hypothesis could not be rejected.

Niii: A larger percentage of patients with congestive heart failure had their CABS within 0-30 days of their index angiography while a smaller percentage had their CABS between 91 days and over ($p < .0001$) than those without this comorbidity and the hypothesis was rejected.

Niv: A larger percentage of patients with previous myocardial infarct had their index CABS within 4-365 days of their index angiography, while a smaller percentage had their index CABS within 0-3 days and over one year ($p < .0001$) than those without this comorbidity and the hypothesis was rejected.

Waiting Time Between Index Angiography and Index CABS

Waiting time is an important policy issue. Almost half (47.6%) of the patients had CABS within 30 days of their index angiography and almost two-thirds (65.4%) had CABS within three months (Figure 12). The largest percentage of patients (35.4%) had their index CABS within 4-30 days of their index angiography. The pre-procedural baseline characteristics of CABS patients were compared by time interval and differences occurred in all variables except income (Table 36).

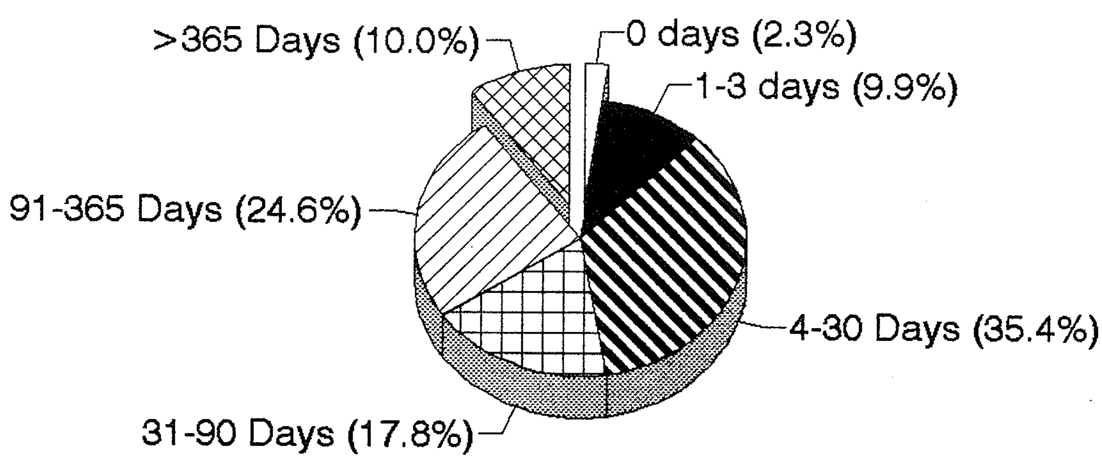

Figure 12. **Time interval between index angiography and index CABS**

Table 36

Comparison of Waiting Time by Sociodemographic Variables for Index CABS Patients

	Waiting Time					
	0	1-3	4-30	31-90	91-365	> 365
N	61	263	942	474	654	267
%	2.3	9.9	35.4	17.8	24.6	10.0
Age	65.1	64.9	64.7	63.4	62.7	62.7*
SD±	9.9	9.5	9.3	9.3	8.9	9.1
Men	44	180	684	352	507	218
%	1.7	6.8	25.7	13.2	19.1	8.2
Women	17	83	258	122	147	49**
%	0.6	3.1	9.7	4.6	5.5	1.8
Rural	19	65	179	121	159	75
%	0.7	2.4	6.7	4.6	6.0	2.8
Western	1	41	114	61	81	19
%	0.0	1.5	4.3	2.3	3.0	0.7
Winnipeg	41	157	649	292	414	173
%	1.5	5.9	24.4	11.0	15.6	6.5
Quintile 1	12	50	162	71	101	40
%	0.5	1.9	6.1	2.7	3.8	1.5
Quintile 2	13	62	190	113	135	68
%	0.5	2.4	7.2	4.3	5.1	2.6
Quintile 3	13	68	204	98	152	51
%	0.5	2.6	7.8	3.7	5.8	1.9
Quintile 4	15	36	185	94	118	59
%	0.6	1.4	7	3.6	4.5	2.2
Quintile 5	8	43	192	95	139	47
%	0.3	1.6	7.3	3.6	5.3	1.8

Note. $^{*}p < .0001$. $^{**}p < .005$.

Hypothesis O: Age was not expected to influence time between index angiography and index CABS. Patients who waited 0-30 days were older than those who waited more than 31 days ($p < .0001$) and the hypothesis was rejected.

Hypothesis P: While no gender differences in waiting time were anticipated, the study found that a larger percentage of women had their index CABS within 0-90 days of their index angiography ($p < .004$) and so the hypothesis was rejected. There was a significant difference in the mean time interval for men ($x = 151.2$) and women ($x = 118.1$) ($p < .004$). There were clearly outliers in this data, and persons who experienced a time interval between index angiography and index CABS of 2031 days or 5.6 years were undoubtedly different from those who had their procedures within a year, and it was decided to trim all time intervals over one year and rerun the analysis. This decision resulted in 267 fewer CABS cases. The difference in mean waiting time between men ($x = 68.8$) and women ($x = 55.9$) remained significantly different ($p < .0003$).

Hypothesis Q: Regional differences in waiting time were not expected but were found ($p < .0001$) and the hypothesis was rejected. Variations in time between index angiography and index CABS occurred across all regions, however no pattern of regional preferential waiting time was found.

Hypothesis R: No relationship was anticipated between income and waiting time and none was found ($p < .382$) and so the hypothesis could not be rejected. The largest percentage of patients (35.4%) had their index CABS within 4-30 days of their index angiography. The mean time interval between index angiography and index CABS was 142.8 days (SD $\pm$ 281. 7 days, range = 0 to 2,031 days, mode = 2 days and median

= 36 days). The distribution of waiting time was skewed and it was thought that patients who waited a year or more were clinically different from those who waited less than a year and so the data was trimmed at one year. Trimming resulted in a loss of 267 CABS patients. It was thought that these patients were treated medically, had repeat angiogram after a year and then were revascularized. Indeed 329 patients had a repeat angiogram after a year and 82 went on to CABS, while 14 had CABS and PTCA. For patients who waited less than a year the mean waiting time was 65.4 days, SD $\pm$ 82.3 days, range = 0 to 365 days, median = 25 days and mode = 2 days. Fifty percent of CABS patients had their revascularization within 25 days and 75% within 99 days.

Mortality

Having investigated the differences in baseline characteristics of CABS patients, the next phase of the study examined the influence of these characteristics on survival. Prior to exploring survival, mortality was examined. Table 37 displays that the total number of patients who died after index CABS (including repeat revascularization) over the course of the study was 312 (11.6%). Case fatality, defined as death within 30 days of the procedure, was 5.6% while the one year mortality rate was 7.8%. Of those who died, 152 (48.7%) died within 30 days. Nearly one third (31.1%) of the deaths occurred within 3 days of the procedure.

Table 37

Patients Dying at Various Time Intervals after Index CABS

Time Interval	Number	Percentage	Cumulative Number	Cumulative Percent
0 Days	40	12.8%	40	12.8%
1-3 Days	57	18.3%	97	31.1%
4-30 Days	55	17.6%	152	48.7%
31-90 Days	21	6.7%	173	55.4%
91-365 Days	28	8.97%	210	64.4%
>366 Days	111	35.6%	312	100.0%

Survival

Follow-up

Only those 3,183 patients who had one therapeutic procedure over the six years of the study were followed in the survival analyses and the average length of follow up was 1,123.65 days (SD $\pm$ 655.2). No differences between the mean follow-up for men and women were found ($p < .41$). For men, the average follow-up was 1,029.53 days (SD $\pm$ 647.6) while for women the average follow-up was 1,007.94 days (SD $\pm$ 675.1).

Over the six years of the study, 341 of these patients died; of these, 91 (26.7%) were PTCA patients and 250 (73.3%) were CABS patients. Mean time to death for PTCA patients was 404.92 days (SD $\pm$ 509.96 days, mode = 0 days, median = 181 days). No significant gender ($p < .07$) or age ($p < .32$) differences were found in PTCA patients who died. For CABS patients the mean time to death was 339.91 days (SD $\pm$ 491.6 days, mode = 0 days, median = 28 days). No significant gender ($p < .66$) or age ($p < .35$) differences were found in CABS patients who died.

Survival Curves

To begin to test the hypothesis of no differences in survival between CABS and PTCA patients after adjusting for sociodemographic and clinical characteristics, survival curves were generated. The curves provide a visual display of the impact of individual variables on survival.

Hypothesis S: Observational studies have consistently reported overall higher CABS mortality than PTCA mortality (Leape et al. 1991), but these studies were flawed not only with weak methodology but with different CAD severity and different endpoints.

Recently, the early results of the first randomized control trials of CABS and PTCA for similar CAD have been published. Mortality and reinfarction is comparable in both procedures but relief of angina and freedom from repeat revascularization was superior in CABS patients (Rodriguez et al. 1992; Hamm et al. 1993). In this retrospective study, it was hypothesized that there would be no differences in the survival of CABS and PTCA patients. Figure 13 displays that CABS patients had a lower probability of 30 day survival ($p < .0001$). Figure 14 displays the six year survival curves; CABS patients had a lower probability of survival at all times ($p < .0001$). Both CABS and PTCA patients had a steady decrease in survival over time, which is likely age-related.

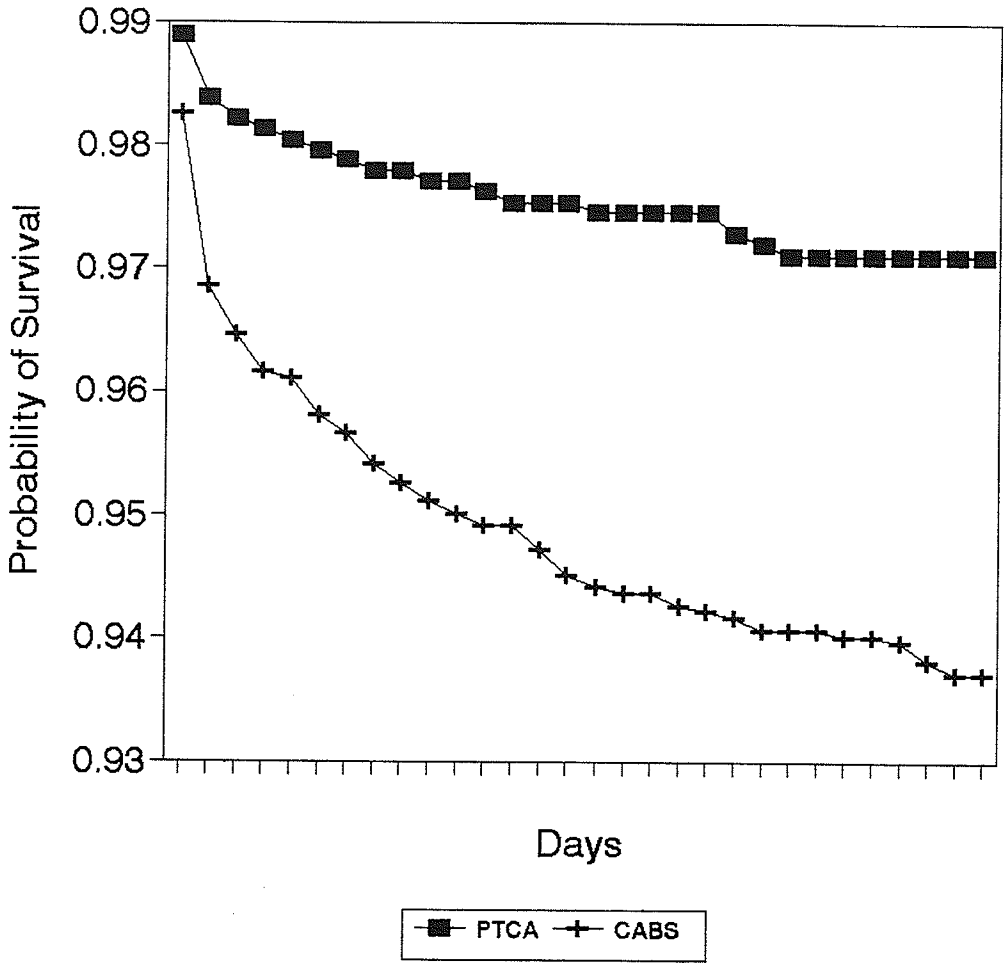

Figure 13. Manitoba 30 day PTCA & CABS survival (FY 1987-1992)

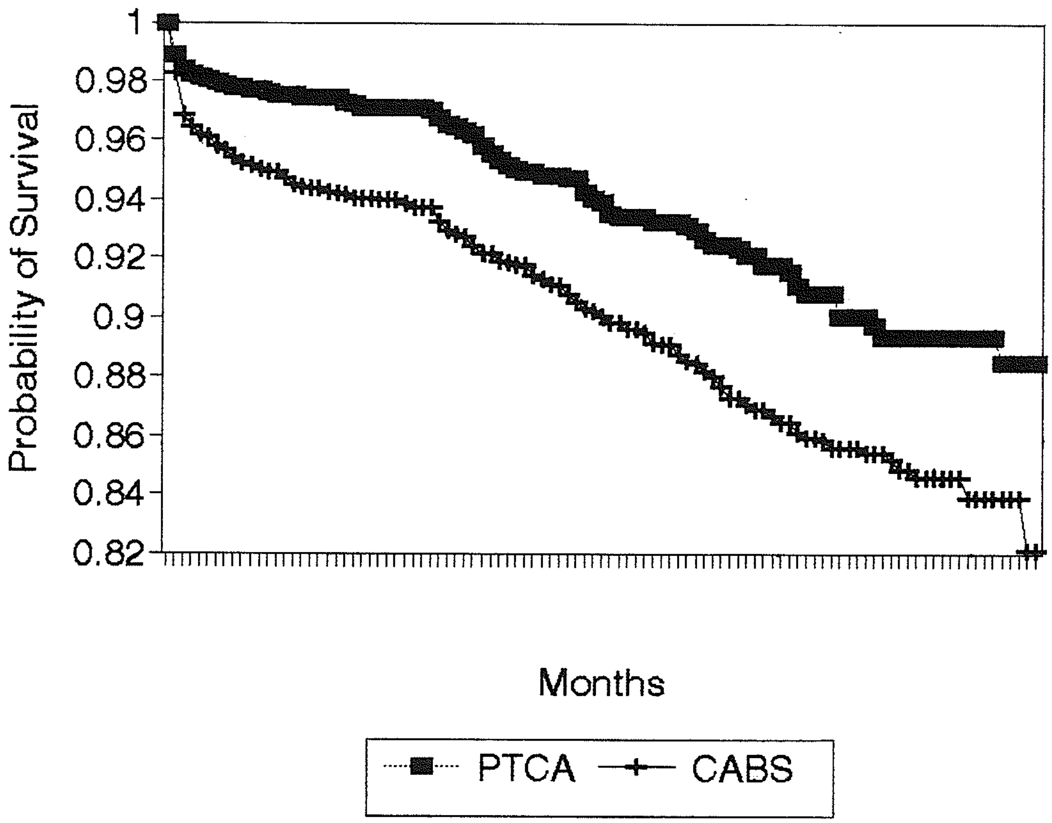

Figure 14. Manitoba six year PTCA and CABS survival (FY 1987-1992)

These findings may not be interpreted as indicating superior survival of PTCA over CABS per se; only a randomized clinical trial of sufficient power could present evidence of procedural effectiveness. Rather, the results indictae that correcting for sociodemographic and clinical differences in baseline characteristics available in the database, these Manitoba survival findings are in the same direction as other studies.

Hypothesis T: Women have consistently had an increased risk of operative mortality; this has been related to their later referral for CABS and their smaller coronary arteries. This study focused on long-term mortality up to six years after the procedure. The null hypothesis was that gender was not expected to affect survival of CABS and PTCA patients. Differences in 30 day survival between male and female CABS and PTCA patients are displayed in Figure 15. Adjusting for gender, women with CABS had a lower probability of survival, followed by men with CABS. Women with PTCA had the next lowest probability of survival while men with PTCA had the highest probability of survival. For both procedures, women had a lower probability of survival ($p < .0002$). This gender difference remained consistent over time and the hypothesis was rejected (Figure 16).

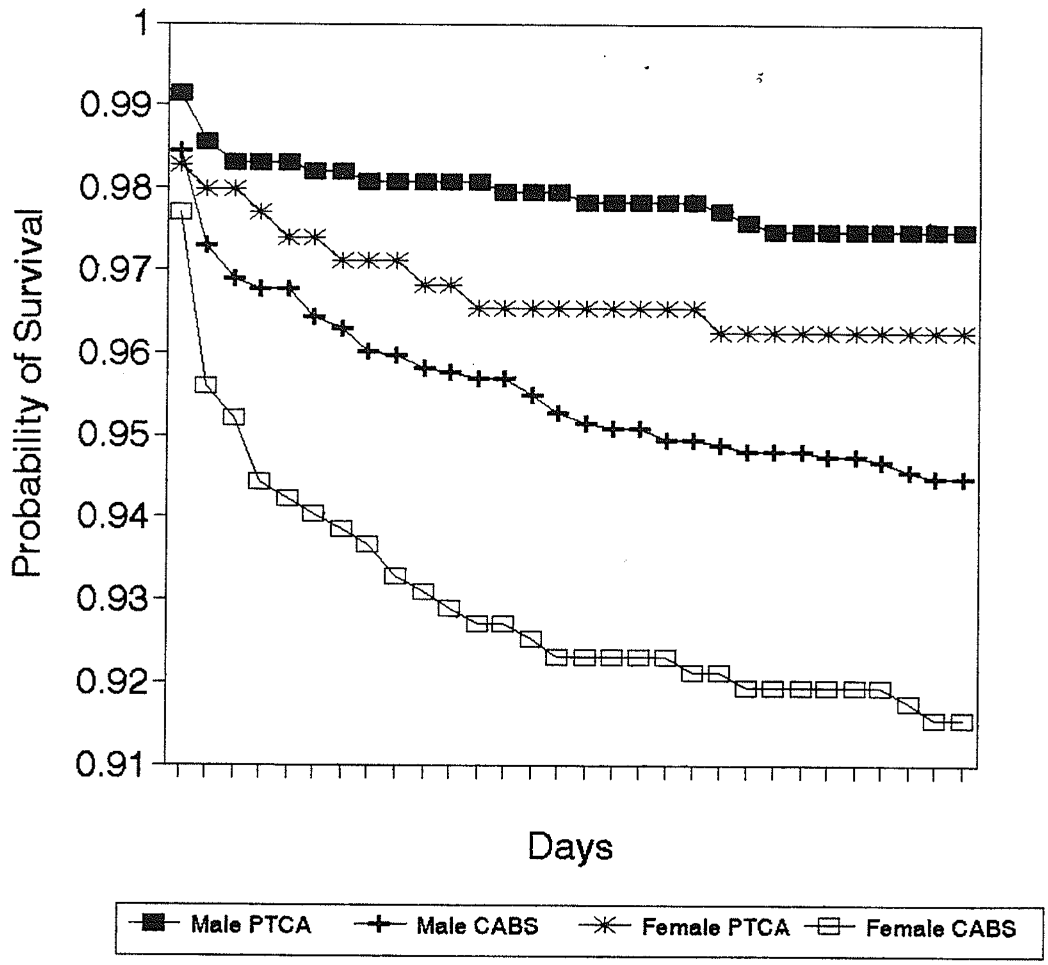

Figure 15. Manitoba 30 day PTCA & CABS survival by gender (FY 1987-1992)

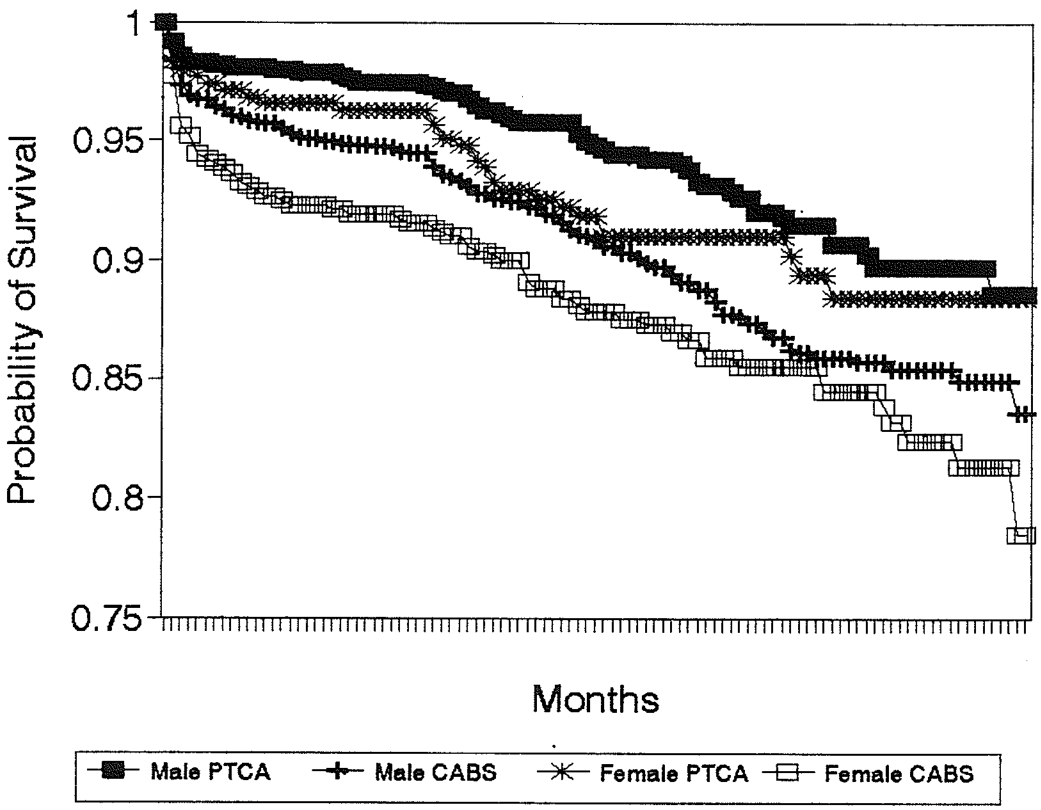

Figure 16. Manitoba six year survival for PTCA & CABS by gender (FY1987-1992)

Hypothesis U: Although age has consistently been a strong predictor of decreased survival, the null hypothesis tested that age would not affect survival of CABS and PTCA patients. Figure 17 displays the 30 day survival curves for CABS and PTCA patients in the three age intervals: (a) 25-65 years, (b) 65-74 years, and (c) 75+ years. Adjusting for age, the probability of survival was lowest for CABS patients 75 years of age and over. This group had a distinctly lower probability of survival than the following four groups: (a) CABS patients age 65-74, (b) PTCA patients age 65 years and older, (c) CABS patients age 25-64, and (d) PTCA patients age 25-64 ($p < .0001$) and the hypothesis was rejected. As would be expected these age differences widened over time (Figure 18).

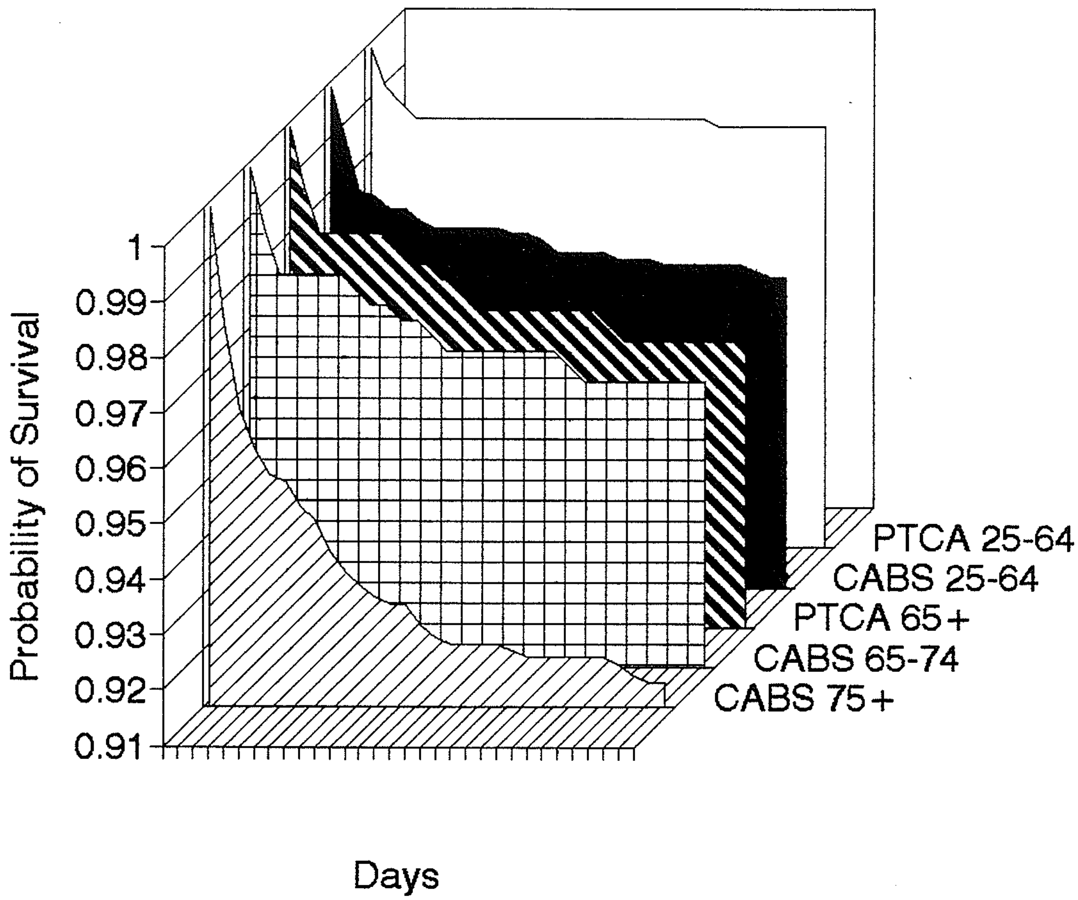

Figure 17. Manitoba 30 day PTCA & CABS survival by age groups (FY 1987-1992)

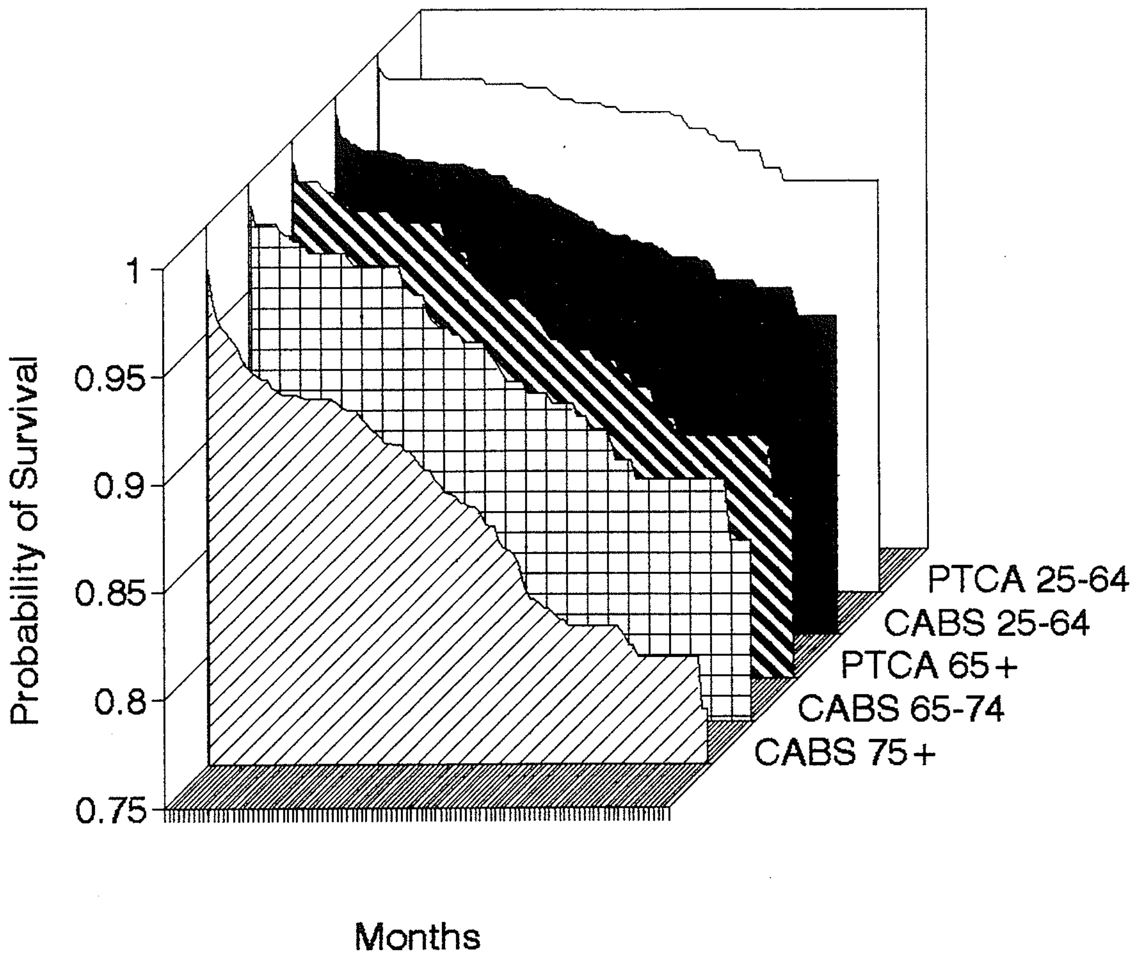

Figure 18. Manitoba six year PTCA & CABS survival by age groups (FY 1987-1992)

Hypothesis V: It was hypothesized that waiting time would not affect survival of PTCA and CABS patients. Figure 19 displays the 30-day survival of patients who waited up to 30 days between index angiography and index PTCA or CABS. CABS patients who had their procedure on the same day had a lower probability of survival, followed by PTCA patients with a 0 day time interval. CABS patients who waited 1-3 days and CABS patients who waited 4-30 days had the next lowest probability of survival. PTCA patients who waited 1-3 days had the second highest probability of survival while PTCA patients who waited 4-30 days had the highest probability of survival ($p < .0001$) and the hypothesis was rejected. Figure 20 shows that the 0 day interval CABS patients continued to have the lowest probability of survival over the six years. Differences in survival were more marked in the years closer to the procedures.

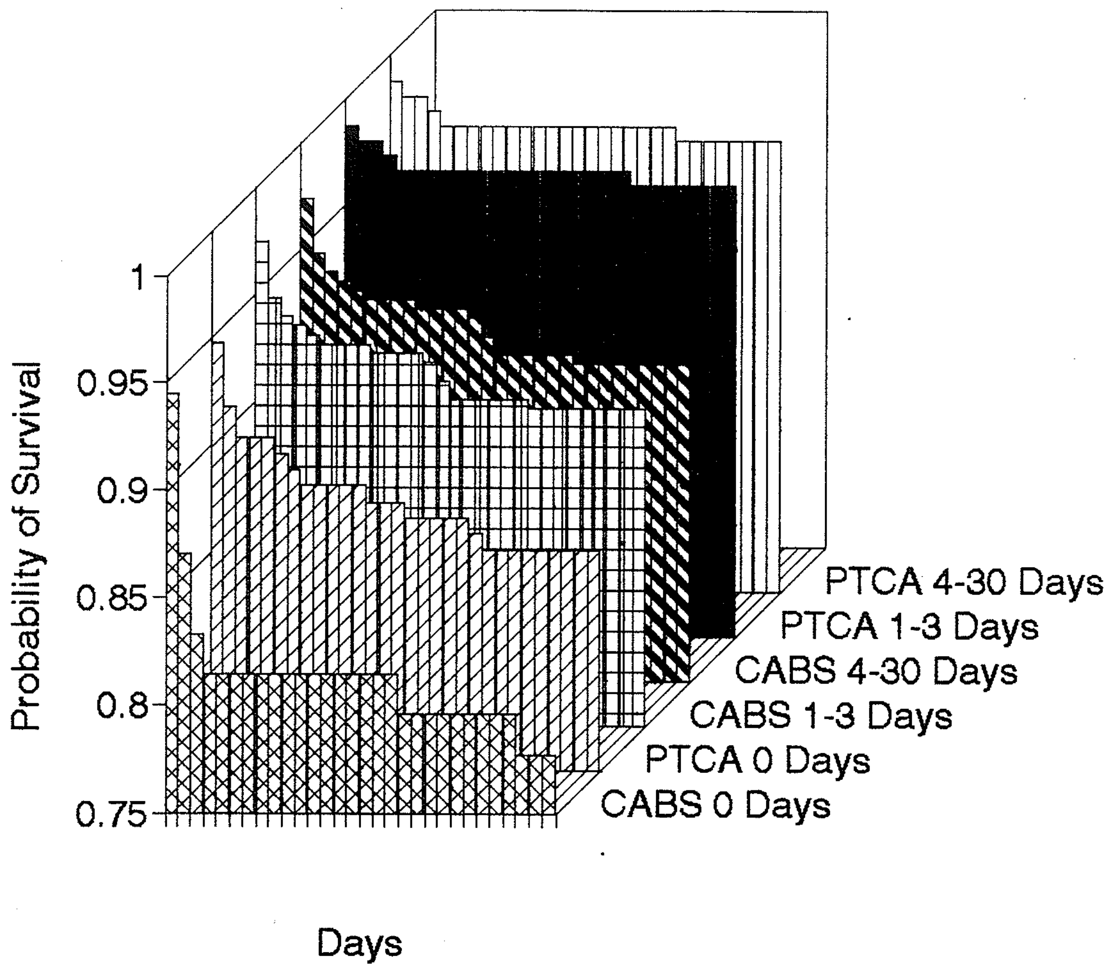

Figure 19. Manitoba 30 day survival after 30 day wait for PTCA & CABS

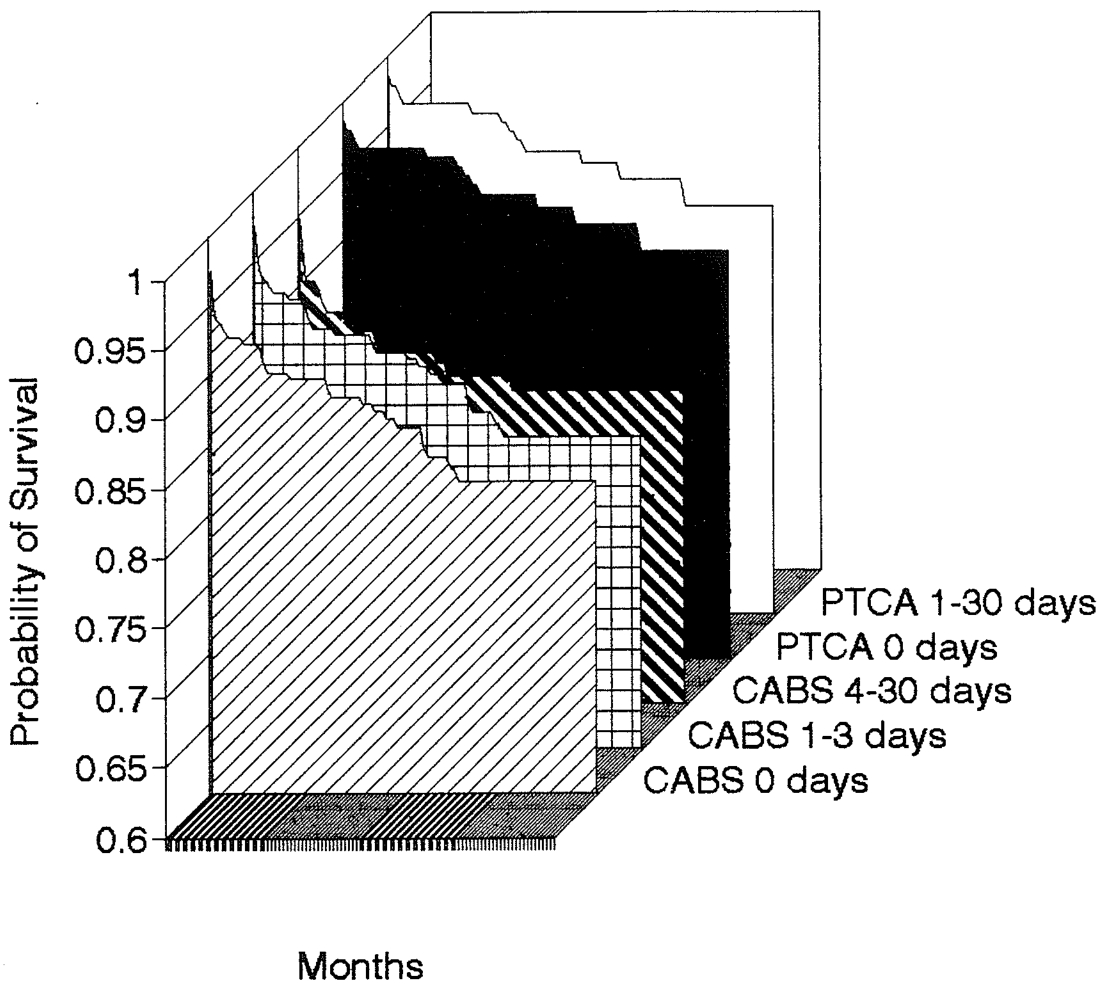

Figure 20. Manitoba six year survival after 30 day wait for PTCA & CABS

Cox Proportional Hazard Survival Analysis

To fully test the hypothesis of no differences between the survival of CABS and PTCA patients adjusting for sociodemographic and clinical variables, eighteen Cox proportional hazard models were calculated using forward stepwise selection in order to assess the best model fit. Covariates used in the model were: (a) procedure, (b) age, (c) gender, (d) income, (e) region of residence, (f) time interval between index angiography and index CABS or index, and (g) comorbidities. Both age and time between index angiography and index PTCA or index CABS were varied in the models.

Model Fit

Table 38 indicates that the use of finer age categories reduced the -2 log likelihood statistic slightly and increased the chi-square slightly. All p values were highly significant and so statistically there was no difference among the models. The 0 day time interval was retained because of its simplicity and the five age groups were retained because from a clinical viewpoint, the additional age parameters were thought to yield distinctive results.

Table 38

Assessing Cox Regression Survival Models Fit

Model	-2 Log Likelihood with Covariates	Chi-Square DF	p Value
	No Comorbidities		
O days base			
2 ages	5177.68	128.22 13 DF	0.0001
3 ages	5170.82	135.08 14 DF	0.0001
5 ages	5167.25	138.66 16 DF	0.0001
0-3 days base			
2 ages	5182.83	123.08 12 DF	0.0001
3 ages	5175.94	129.96 13 DF	0.0001
5 ages	5172.55	133.35 15 DF	0.0001
1-3 days base			
2 ages	4540.96	109.74 12 DF	0.0001
3 ages	4535.81	114.64 13 DF	0.0001
5 ages	4527.98	122.72 15 DF	0.0001
	Comorbidities		
0 days base			
2 ages	5041.34	210.38 18 DF	0.0001
3 ages	5037.87	213.85 19 DF	0.0001
5 ages	5033.88	217.85 21 DF	0.0001
0-3 days base			
2 ages	5046.55	205.17 17 DF	0.0001
3 ages	5043.14	208.58 18 DF	0.0001
5 ages	5039.31	212.42 20 DF	0.0001
1-3 days base			
2 ages	4441.07	190.01 20 DF	0.0001
3 ages	4438.54	192.54 21 DF	0.0001
5 ages	4431.60	199.48 23 DF	0.0001

Stability of the Model

A split-half proportional hazards model with 0 days time interval as base was run in order to test the stability of the model; data were divided into three year time periods: a) 1987-1989 and b) 1990-1992. It was anticipated that the split-half model would not be quite as stable as the full model because the truncation bias would be spread over the two halves. There were no statistical differences between the 1989 and the 1992 models indicating that the results were stable.

Main Effects and Interactions

Interactions were also tested for by forcing all main effects and interaction terms into the model. Because a significant relationship between: (a) income and gender, and (b) age and gender had been found in the descriptive analyses, these interactions were tested using the 0 day time interval reference model. An income and age interaction was also tested. The age-by-gender and gender-by-income interactions were not significant in either the model with or without comorbidities. Because of the small sample sizes, in testing the age-by-income interaction, three age variables and two income variables were used: (a) 25-64, (b) 65-74, (c) 75+, (d) quintile 1, and (e) quintile 5.

Hypothesis W: In the model without comorbidities, CABS had a 1.66 risk ratio (Table 39) and the hypothesis could not be rejected. Increasing age conferred an increasing risk ratio; (a) age 65-74 (RR = 2.383), and (b) age 75+ (RR = 3.100). However, the risk ratio for age 75+ fell within the confidence interval for age 65-74 and could be collapsed into a single age 65+ variable (RR = 2.383). Waiting more than one day between index angiography and index CABS or index PTCA resulted in decreased risk ratios. Because the risk ratio for 4-30 days (RR = 0.542) fell within the confidence interval of 1-3 days (95% CI, 0.402-0.929), these time intervals could be collapsed into one variable, 1-30 days (RR = 0.611). Similarly, the risk ratio for 91-365 days (RR = 0.387) fell within the confidence interval for 31-90 days (95% CI, 0.251-0.578), these could be collapsed into 31-365 days (RR = 0.381). Thus waiting 1-30 days had a 61% decreased risk of death as compared to having the procedure on the same day and waiting 31-365 days reduced the risk by 38%.

The interaction term Income5 by Age75 (RR = 2.401) was significant in the model without comorbidities. While no income variables were significant as main effects in either models, the interpretation of an elevated risk ratio for older wealthier patients is not apparent.

Table 39

Comparison of Independent Predictors of Death After Index PTCA or CABS With and Without Comorbidities (0 Days Reference)

Model Covariate	Risk Ratio (95% Confidence Interval)	p Value
	No Comorbidities	
CABS	1.669 (1.295-2.149)	0.0001
Age 65-74	2.383 (1.810-3.138)	0.0001
Age 75+	3.100 (2.193-4.382)	0.0001
Time 1-3 Days	0.611 (0.402-0.929)	0.0212
Time 4-30 Days	0.542 (0.383-0.767)	0.0005
Time 31-90 Days	0.381 (0.251-0.578)	0.0001
Time 91-365 Days	0.387 (0.250-0.599)	0.0001
Income5*Age75+	2.401 (1.057-5.455)	0.0363
	Comorbidities	
Age 65-74	2.142 (1.622-2.830)	0.0001
Age 75+	2.506 (1.759-3.570)	0.0001
1-3 Days	0.606 (0.394-0.930)	0.0220
4-30 Days	0.601 (0.421-0.860)	0.0053
31-90 Days	0.452 (0.294-0.693)	0.0003
91-365 Days	0.475 (0.303-0.743)	0.0011
Coagulopathies	2.543 (1.550-4.170)	0.0002
CHF	2.882 (2.250-3.692)	0.0001

When comorbidities were introduced into the model, the main procedure effect was not significant and the hypothesis was rejected. The interaction term income5-by-age75+ was not significant; however two comorbidities, coagulopathies (RR = 2.543) and congestive heart failure (RR = 2.882) were significant. The age and waiting time variables remained significant but their risk ratios declined slightly.

Discussion

Sociodemographic Characteristics

Gender

Gender differences were found in all pre-procedural baseline sociodemographic characteristics. The majority of CABS patients were men and they were more likely than women to proceed to CABS after index angiography. Because angiography is the screening procedure for CABS, it acts as a funnel and the gender difference in CABS utilization is related to the gender difference in angiography utilization. If these differences represented a gender referral bias, CABS women have more serious CAD which in turn would lead to higher mortality.

Women who had CABS had a different sociodemographic profile than men. They were, on average, 3.3 years older than men. This age difference reflects the protective effect of estrogen on the incidence of CHD in pre-menopausal women. The regional gender difference that existed in angiography carried over to CABS and again, a larger percentage of women and a smaller percentage of men who resided in Winnipeg had CABS. A regional gender referral bias appears to be operating against women outside of Winnipeg. This may reflect physicians' knowledge of the earlier literature which reported higher mortality rates for CABS in women due to their later and more severe CAD presentation (Lerner & Kannel, 1986) and smaller body mass. However, neither region nor gender was found to be an independent risk factor in this study. Physicians outside of Winnipeg who are in a position to refer patients for angiography and CABS may benefit from continuing education about the advantages of CABS in women.

While the percentages of men and women from income quintiles 2, 3 and 4 were equivalent, significant differences were found in the upper and lower income quintiles. The smallest percentage of men were from quintile 1, while the largest percentage were from quintile 5. Conversely the largest percentage of women were from quintile 1 and the smallest from quintile 5. Since the literature reports an inverse relationship between income and CAD, the findings in women from poorer neighbourhoods are appropriate but the findings in men from wealthier neighbourhoods are atypical. These findings reflect the funnel effect that was begun with the screening procedure, angiography: an income referral bias in men is operating and men from wealthier neighbourhoods are advantaged in their referral patterns. If men from poorer neighbourhoods who receive CABS have more severe CAD, then they may have an elevated risk of mortality. But neither income nor gender nor their interactions conferred a significant increased risk of mortality. Whether CABS performed in men from wealthier neighbourhoods is appropriate cannot be measured with this data; neither can this data detect if men from poorer neighbourhoods with appropriate indicators for CABS are being denied access.

Higher mortality rates in women have been attributed to differences in baseline characteristics (Khan et al. 1990). Survival curves confirmed that gender affected survival; when gender was the single variable controlled for, women had a lower probability of survival for both CABS and PTCA. When all covariates were entered into the survival model in this population-based study, gender was not predictive of decreased probability of survival. Thus, while there were significant differences in all of the sociodemographic characteristics of women, the effects of gender disappeared when other variables were controlled for and gender did not predict differential probability of survival.

Age

As expected there was a strong age effect on utilization of, and outcomes associated with, CABS. On average women were three years older than men. Age-related utilization of CABS reflects the natural history of CAD; younger men (age 35-44 years) were two and a half times as likely as women to have CABS after angiography but by age 65 and over, the percentage of women having CABS was greater than men. CABS utilization increased by 11.4% in the elderly and decreased by 11.4% in the non-elderly. This shift in utilization occurred in spite of the fact that randomized clinical trials have yet to demonstrate the efficacy of CABS in the elderly. The shift in CABS utilization to the elderly occurred in spite of "capping" of the procedure; the growth curve for CABS was flat over the six years of the study reflecting a freeze in resources allocated to CABS.

Age was an important independent predictor of death; in the model with no comorbidities, patients aged 65 and over had an elevated risk ratio of 1.6. An interaction between income quintile 5 and age 75 and over conferred almost two and a half (2.4) times an elevated risk of mortality. This interaction disappeared when comorbidities were entered into the survival model and no explanation is apparent for the interaction. The strength of the age variable can be recognized in the model with comorbidities. Even when comorbidities are controlled for, age 65 and over had an elevated risk ratio of 2.1.

Region of Residence

In a province where cardiac services are centralized in the two teaching hospitals in Winnipeg, access to these services from outside Winnipeg is critical. In comparison to the regional distribution of the general population aged 25 and over, there were fewer patients from Other Rural Regions and the Western Region and more from Winnipeg referred for CABS. This regional referral bias indicates preferential access for Winnipeg residents and stems from the regional referral bias operating at the angiography level and is supportive of an angiography funnel effect.

As already reported, a regional gender referral bias was operating against women outside Winnipeg and is likely related to the angiography funnel effect and reflects different selection criteria. While the mean age of CABS patients from Other Rural Regions was significantly younger than patients from the Western Region and Winnipeg, this age difference was not clinically relevant since the mean ages of patients from all regions was under 65 and the survival analysis demonstrated reduced risk of mortality in the under 65 age group. Regional differences in the income distribution of CABS patients existed and will be discussed later. In spite of the baseline regional differences in gender, age and income, the differences were not consistently attributable to one region and region was not an independent predictor of increased mortality.

Income

There were differences in the distribution of CABS patients across income quintiles from that of the general population, however not in the direction that was anticipated from the literature. There were more patients from quintiles 2 and 3 and fewer from quintiles 1, 4 and 5. This mirrors the pattern for angiography and is again supportive of an angiography funnel effect. The finding that fewer patients from the poorest neighbourhood had CABS is disquieting as they would be expected to have the highest utilization due to their higher incidence of CAD reported in the literature. Since national health insurance guarantees payment for service, income should not be a barrier to CABS in Canada. Other reasons postulated for this finding are increased CAD risk factors or comorbid disease in the poor coupled with constrained resources may lead physicians to select patients with more potential for recovery. As well, patients from poorest neighbourhood may prefer medical treatment as opposed to surgical treatment. There may be more of a willingness to take early retirement in the poor; these speculations require further study. On the other hand, this finding may represent random fluctuation; there is no basis for thinking that an income selection bias is operating since fewer patients from the wealthiest neighbourhoods (quintiles 4 and 5) also had lower utilization. The fact that the largest proportion of CABS patients were from quintiles 2 and 3 is likely related to the fact that patients from these quintiles were significantly older than patients from quintile 5 and is likely associated with increased utilization in the elderly.

As previously discussed, an income differential in CABS utilization was found for men and women. Patients from quintile 5 were significantly younger than patients from quintiles 2 and 3. Regional differences in income distribution of CABS patients were also noted and this finding generates serious concern. Outside Winnipeg, the distribution of income reflected the relationship between CAD and socioeconomic status reported in the literature, that is, poorer citizens have increased incidence of CAD and thus increased utilization of CABS was expected in the lower income quintiles and occurred. However the finding that, in Winnipeg, patients from wealthier neighbourhoods had increased utilization of CABS contradicts the literature (Logue & Jarjoura, 1990; Eames et al. 1993) and may indicate increased patient demand or an income referral bias. If Winnipeg patients from wealthier neighbourhoods have less severe CAD but were less willing to tolerate angina symptoms and were requesting CABS, two fundamental questions remain to be addressed. The first question is whether patients from poorer neighbourhoods within Winnipeg were being denied access to CABS. If finite resources were maldistributed because of differential access, this is a serious concern. Indeed, a smaller percentage of Winnipeg patients from quintiles 1 and 2 had CABS than from the other two regions and this finding is supportive of an income referral bias within Winnipeg. If Winnipeg patients from poorer neighbourhoods were found not to have differential access, this could have indicated excess resource capacity.

The second question to be addressed concerning the regional differences in the income distribution of CABS patients is whether the indications for CABS in Winnipegers from wealthier neighbourhoods are appropriate. Appropriateness of CABS cannot be answered with the data available (Leape et al. 1991). However since neither region of residence nor income was an independent predictor of survival when all covariates were controlled for, Winnipeg patients did not incur either greater or lesser risks. However, this simply addresses the risks of those patients who had the procedures. The fate of Winnipeg patients from poorer neighbourhoods who may have been denied CABS is unknown.

And so a profile emerges of differential access by young, wealthy, male Winnipegers. This database lacks other clinical and socioeconomic variables which might help to explain this phenomena. Do young, wealthy, male Winnipegers have a CHD risk profile that is higher or lower than others? Are their clinical symptoms more severe? Are they less willing to tolerate CAD symptoms? Are more of them self-employed and lacking disability benefits? Further study is required to address such factors to explain this variation.

These findings should be tempered by the fact that the income distribution in the regions may differ from the distribution in the province as a whole. Only by adjusting for these differences, can regional variations be assessed. In Chapter 3, the Rates Chapter, when income-adjusted regional rates were examined on an annual basis, only in 1989 was a significant difference between Winnipeg (with the highest utilization rates) and the Western Region (with the lowest rates) found. A final question to be posed, is whether the variation is simply an artefact of regional differences in income distribution; the results of the rates chapter lend credence to this interpretation. The strongest evidence comes from the survival analyses; in no model is income found to be a main effect. When comorbidities are not entered into the model, a 2.4 increased risk factor for an interaction between highest income and oldest age is found. However, when comorbidities are entered into the model, this interaction disappears. Do elderly CABS patients from the most affluent neighbourhoods have more comorbidities? It is possible that the patients who survive to old age to have CABS or PTCA are from wealthy neighbourhoods, and that even though they have survived other causes of mortality, they present with CAD and comorbid disease? This interpretation is in keeping with the documented increased survival in the wealthy.

Clinical Characteristics

Comorbidities

While nine comorbidities were recorded in at least 1% of CABS, only four occurred in sufficient numbers to conduct tests of differences: (a) diabetes (2.4%, n = 65), (b) coagulopathies (3.7%, n = 101), (c) congestive heart failure (14.5%, n = 391), and (d) previous myocardial infarction (21.9%, n = 590). Diabetes and congestive heart failure were more prevalent in women and since these diagnoses are age-related, their increased prevalence is likely related to the fact that women were older than men at index CABS. Previous myocardial infarction was more prevalent in men which is supportive of the different IHD presentation in women and women's lower myocardial infarction rates as reviewed in Chapter 1. Previous myocardial infarction, the only comorbidity to vary across regions, was more prevalent in Winnipeg and this finding may indicate different regional diagnostic criteria for utilization of CABS. Two comorbidities differed in a non-systematic manner across income quintiles: a larger percentage of patients with coagulopathies were from quintiles 2 and 5 and a smaller percentage were from quintiles 1, 3 and 4 and more CHF patients were from the poorer quintiles 1 and 2 while fewer were from quintiles 3, 4 and 5.

Significant differences in waiting time between index angiography and index CABS were found in two comorbidities; congestive heart failure and myocardial infarction. More congestive heart failure patients had their index CABS within 0-30 days of their index angiography while fewer previous myocardial infarction patients had theirs within 0-30 days. There is no consensus in the literature about the efficacy of CABS in the immediate post-AMI period especially since the introduction of thrombolytic therapy (Leape et al. 1991). The longer waiting time for previous AMI patients in this study may reflect this lack of consensus and may also indicate that these patients were stable. The stability premise is supportive by the fact that previous AMI did not confer an elevated risk ratio in the survival analysis. The shorter wait of CHF patients may reflect the urgency of their condition and this is supported by the finding that CHF patients had a 2.9 elevated risk ratio, while waiting over 1 day between index angiography and index CABS decreased the risk ratio. Congestive heart failure confers its own unique, independent, increased risk of death as does the presence of coagulopathies (RR = 2.5). However, without knowing the extent of CAD in the patients, it is not possible to interpret the differences in waiting time in CHF and AMI patients.

<u>Time Interval between Index Angiography and Index CABS</u>

Almost half (47.6%) of the patients had CABS within 30 days of index angiography and almost two-thirds (65.4%) had CABS within three months. Quantifying waiting time and examining differences in baseline characteristics of patients with varying waiting times was a unique contribution of this study. Gender differences in waiting time were found; more women had CABS within 0-90 days or after 365 days than men. The fact that women waited less time than men suggests that women had more severe CAD.

Age differences in waiting time occurred; more younger patients waited over 31 days while more older patients had their CABS within 0-30 days of their index angiography. While this age difference was statistically significant, it is not clinically significant. The mean age ranged from a low of 62.7 years at time between 91-365 days to a high of 65.1 years at 0 days: age under 65 did not confer an elevated risk ratio in the survival analysis. As previously discussed, two comorbidities differed in their waiting time: CHF and previous AMI.

Of importance were those negative findings regarding waiting time; no differences between income quintiles and waiting time were found. This finding reinforces one of the principals of the Canada Health Act: equity. While regional differences in waiting time occurred, no one region predominated and random fluctuation is the most likely explanation.

The impact of waiting time on survival was a unique dimension of the study. Survival curves confirmed that waiting time affected survival; when 30 day waiting time between index angiography and index CABS was the single variable controlled for, CABS patients who waited 0 days had the lowest probability of survival, followed by PTCA patients who waited 0 days. As waiting time increased, survival increased, although in each time interval CABS patients had the lower probability of survival.

When waiting time was entered into the model without comorbidities, two time intervals had decreased risk ratios in comparison to the referent case of 0 days waiting time: (a) 1-30 days (RR = 0.611), and (b) 31-365 days (RR = 0.381). When waiting time was entered into the model with comorbidities, patients who waited 1-365 days had a slightly decreased risk ratio (RR = 0.0606). Even after adjusting for comorbidities, not having index CABS or PTCA on the same day as index angiography increased the probability of survival by nearly 40%. Clearly, patients who had the procedures on the same day were at increased risk; however, this database does not provide information about the extent of CAD. Physicians prioritised patients who would not be in jeopardy if they waited. The results of the waiting time analyses are supportive of physicians' clinical decision-making skills as patients with higher risks were operated on immediately while those with less severe CAD were appropriately selected to wait.

Chapter 6

Rates

Introduction

This chapter describes utilization and case fatality rates for angiography, coronary artery bypass surgery (CABS) and percutaneous transluminal coronary angioplasty 21-225 (PTCA) occurring in Manitoba during fiscal years (FY) 1987/88 to 1992/93. Arising from the literature review, the effects of age, gender and income on utilization rates were examined. Time trends and regional patterns were also explored. To begin, unadjusted mean utilization rates for each of the procedures provided a provincial perspective over the study period. Annual growth rates in the three procedures were also calculated.

Age was the first focus in examining utilization; provincial, annual, age-specific utilization rates for the three procedures was explored to assess whether changes in age-related referral patterns noted in the literature also occurred in Manitoba. Since the rates were calculated using population data, testing for statistical differences is not considered necessary by most authors (Anderson, Newhouse & Roos, 1989; Anderson et al. 1993; Ugnat & Naylor, 1993). In order to correct for variations in age distribution in the regions, the crude rates were standardized to the age-distribution of the province. The terminology, crude and specific rates, are synonymous while adjusted and standardized rates are also equivalent.

Gender was the second focus in the examination of rates. Provincial annual gender-specific utilization rates for the three procedures allowed the question raised in the

the literature about gender differentials in referral patterns to be addressed in Manitoba. To correct for gender variations in the regions, the crude rates were standardized to the gender distribution in the province. The question posed was: when we correct for gender though standardization, are there differences in the regional rates?

The issue of equity was addressed by describing provincial, annual, income-specific utilization rates for the three procedures. Regional income-specific rates were standardized in order to correct for variations in income distribution in the province. Because coronary artery procedures are centralized in Winnipeg and regional variations in two of the procedures have previously been noted without variation in underlying regional IHD rates (Roos & Sharp, 1989), it was important to examine whether regional disparities in utilization have persisted. Here the question was: are regional differences due to demographic differences in age, sex and income? If rate differences persist after adjustment, this would be indicative of variation in service delivery. The final review of regional utilization looked at procedural time trends.

Case fatality rates were also calculated. This study examined 30 day annual, regional case fatality rates to assess whether differences occurred among the regions and over the study period. One year annual, regional case fatality rates are an indicator of long-term follow-up care and were also calculated in order to enhance comparisons with other jurisdictions. The probability of having an angiogram and the probability of proceeding to revascularization for men and women, once index angiography has been performed, was calculated.

Methods

Baseline differences in the mean age, gender and income of patients having the three procedures were noted in Chapters 3, 4 and 5. Whether these differences are attributable to underlying differences in the distribution of these variables in the population as a whole, is the topic of this chapter. The data used in this chapter includes all angiography, CABS and PTCA performed in Manitoba during FY 1987/88 to 1992/93. Thus, the data differs from that used in other chapters in that angiography was not used as a screen for entry into the study. An important difference in this data set is that for CABS procedures, concurrent valve procedures are also included.

In order to adjust for differences in the age and sex distribution of the regions, the rates were standardized to the Manitoba population as a whole. Standardization enhances comparisons of rates over time whereas crude or specific rates could be cumbersome to deal with; standardization also minimizes the problem of relatively small numbers and their resulting fluctuations and imprecisions (Fleiss, 1973). To calculate age-adjusted rates using the direct method, the age-specific rates of utilization in the regions are multiplied by the age-specific provincial population to obtain the age-standardized, regional utilization rates (Mausner & Kramer, 1985). The "Rates Macro" available at the Manitoba Centre for Health Policy and Evaluation in 1993 was used to calculate the rates (Roos & Roos, 1986). An argument could be made that due to the small numbers of deaths that occurred in some age groups, (in fact there were no deaths in some groups) that the indirect method of standardization should be used. However, there were minimal differences among crude, direct-adjusted and indirect-adjusted rates.

The referent population used in standardization was the population from the mid-point year, that is, the December 1989 population over 25 years of age from the MCHPE registry: a total of 713,392 persons. Adjustment using Statistics Canada's census income quintiles was also conducted in order to assess whether income affects utilization. Manitoba was divided administratively into seven health regions at the beginning of the study period. Previous research had shown that the Western Region (Westman and Parkland Regions) had the lowest adjusted rates of angiography and CABS in the province (Roos & Sharp, 1989) and since there were relatively few numbers of CABS and PTCA performed annually, the seven health regions were collapsed into three. The three regions and their adult populations were: (a) Other Rural Regions (Central, Eastman, Interlake and Norman, n = 189,767), (b) Western Region (n = 105,778), and (c) Winnipeg (n = 417,847).

Since age, gender, income and region were entered as covariates in the proportional hazards model in an earlier chapter, and since proportional hazards analyses accounts for loss to follow-up (censoring), logistic regression was not used to calculate odds ratios for these covariates. The risk ratios associated with the individual covariates and interactions between covariates were calculated in the survival analyses.

Results

Utilization Rates

Unadjusted Mean Provincial Rates

Unadjusted mean provincial utilization rates per 10,000 population, aged 25 and over the study period were: (a) 28.9 for angiography, (b) 6.5 for CABS, and (c) 6.0 for PTCA. Table 40 displays the crude, regional, mean utilization rates relative to the province; Winnipeg ranks #1 with the highest rates, the Other Rural Region ranks #2 and the Western Region consistently ranks #3 with the lowest rates.

Table 40

Crude Mean Provincial Utilization Rates for Coronary Angiography, CABS and PTCA per 10,000 Population, Relative to Province (FY 1987/88-1992/93)

	Procedure		
Region	Angiography	CABS	PTCA
Other Rural (2)	0.99	0.95	0.91
Western (3)	0.79	0.86	0.76
Winnipeg (1)	1.22	1.19	1.34
Province	1.00	1.00	1.00

Annual growth in utilization rates for each procedure is displayed in Figure 21. The extremal quotient is commonly used to describe the distribution of rates and is calculated by dividing the highest rate in the distribution by the lowest (Volinn, Diehr, Ciol & Loesser, 1994). Because trends in utilization over time were an important area of inquiry, the extremal quotient was used to compare the rates in 1992/93 to those in 1987/88. Since there was much variability in the rates in different years, an annual rate may indeed have been higher or lower in other years, but only the endpoints were used to calculate the extremal quotient. Angiography rates grew the fastest over the study period followed by PTCA rates and CABS rates. From 1987/88 to 1992/93, a 45% increase in crude angiography utilization rates, a 16.4% increase in CABS utilization and a 27.5% increase in PTCA rates occurred.

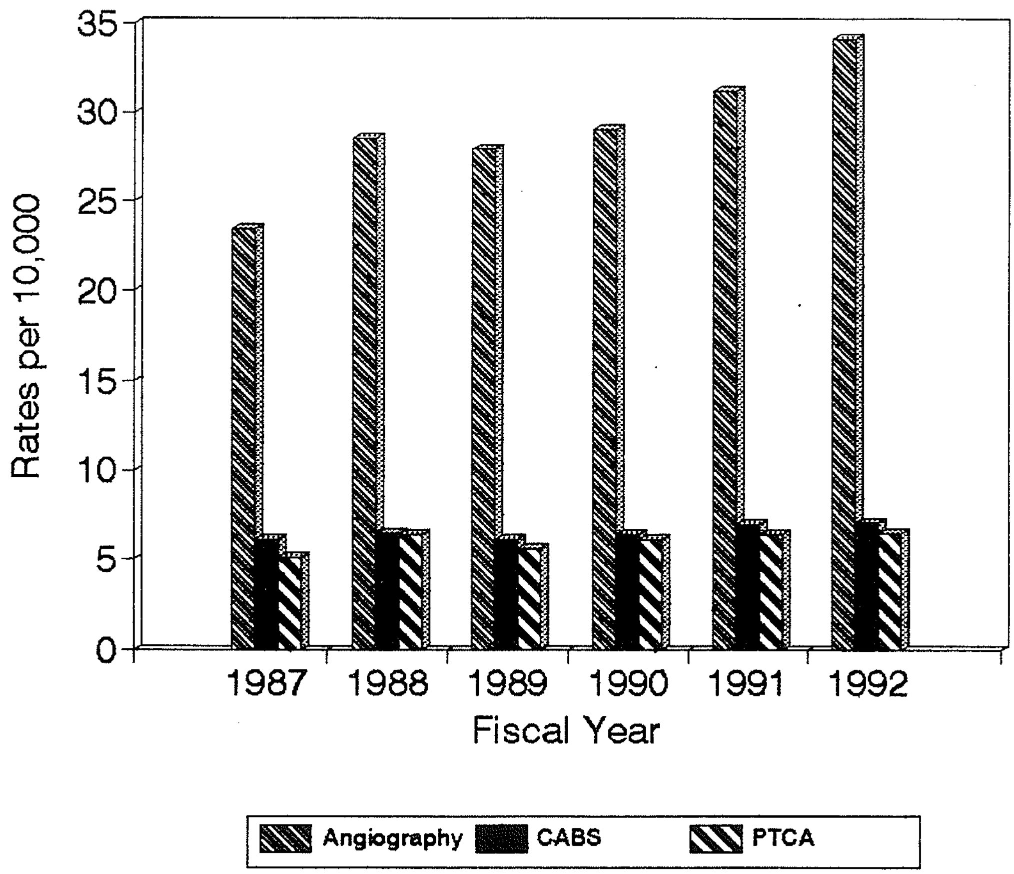

Figure 21. Annual provincial crude angiography, CABS & PTCA utilization rates

Age

Age-Specific Provincial Rates. The first issue to be addressed was whether temporal variation in rates occurred in any age group. Annual, age-specific, provincial angiography rates are displayed in Figure 22. The highest utilization rates occurred in the 65 to 74 age group. Between 1987/88 and 1992/93, there was a: (a) 54.4% increase in the 25-34 age group (not displayed because of small numbers), (b) 14.8% increase in the 35-44 age group, (c) 38.6% increase in the 45-54 age group, (d) 13.3% increase in the 55-64 age group, and (e) 61.5% increase in the rates in the 65-74 age group. The largest increase, 194%, occurred in the 75 and over age group.

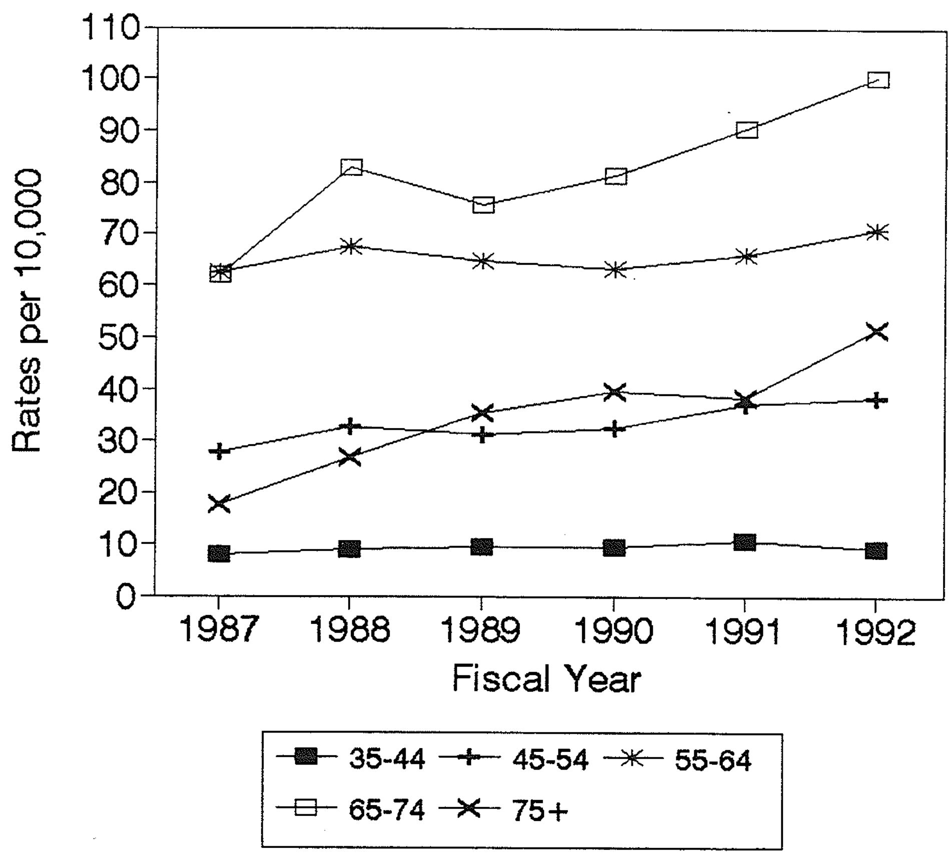

Figure 22. Annual age-specific provincial angiography utilization rates

Annual age-specific provincial utilization rates for CABS are displayed in Figure 23. The highest utilization rates occurred in the 65 to 74 age group and growth in utilization occurred only in the elderly. Between 1987/88 and 1992/93, there was a: (a) 75% decrease in CABS utilization in the 25-34 age group (not easily apparent because of small numbers), (b) 30% decrease in the 35-44 age group, (c) 1.8% decrease in the 45-54 age group, (d) 5.5% decrease in the 55-64 age group, (e) 28.5% increase in the 65-74 age group, and (f) 105.6% increase in the 75 and older age group.

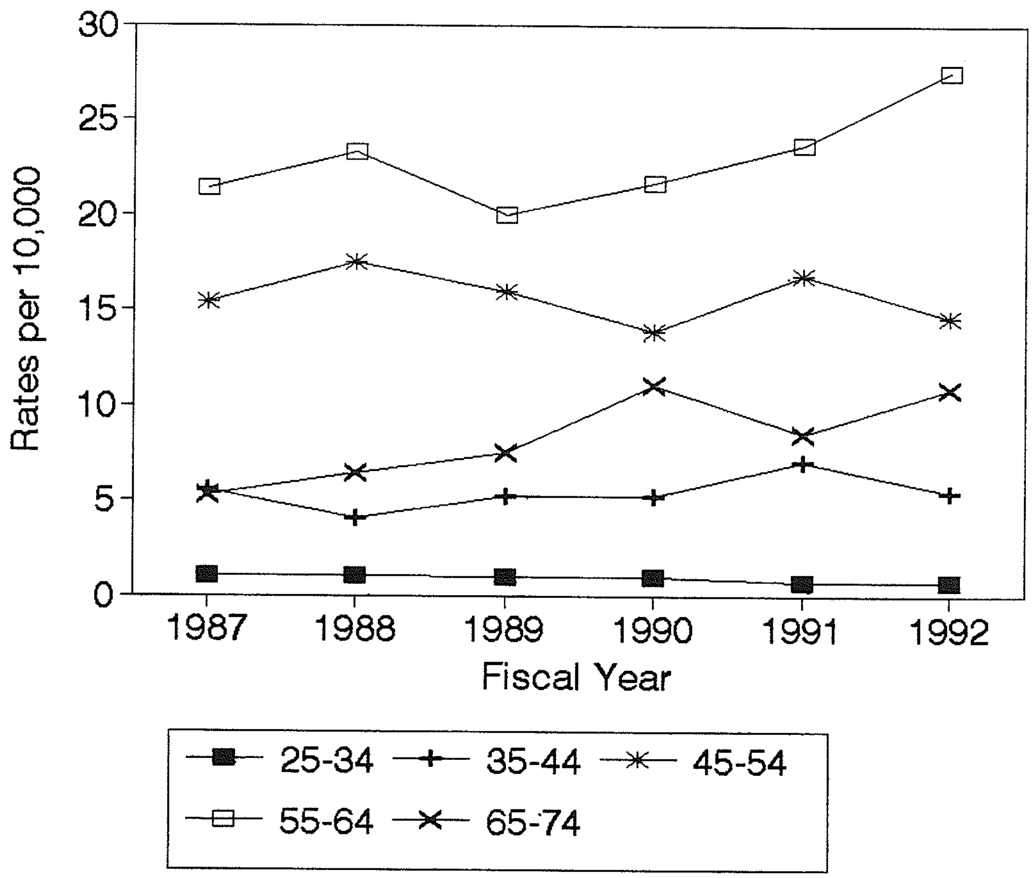

Figure 23. Annual age-specific provincial CABS utilization rates per 10,000

Figure 24 displays the annual, age-specific, provincial PTCA utilization rates over the study period. The 65 to 74 age group had the highest utilization rates. Between 1987/88 and 1992/93, there was a: (a) 66.6% decrease in the 25-34 age group (not displayed because of small numbers), (b) 4.8% increase in the 35-44 age group, (c) 12.3% increase in the 45-54 age group, (d) 11.1% increase in the 55-64 age group, (e) 37.8% increase in the 65-74 age group, and (f) 241.7% increase in those aged 75 and older.

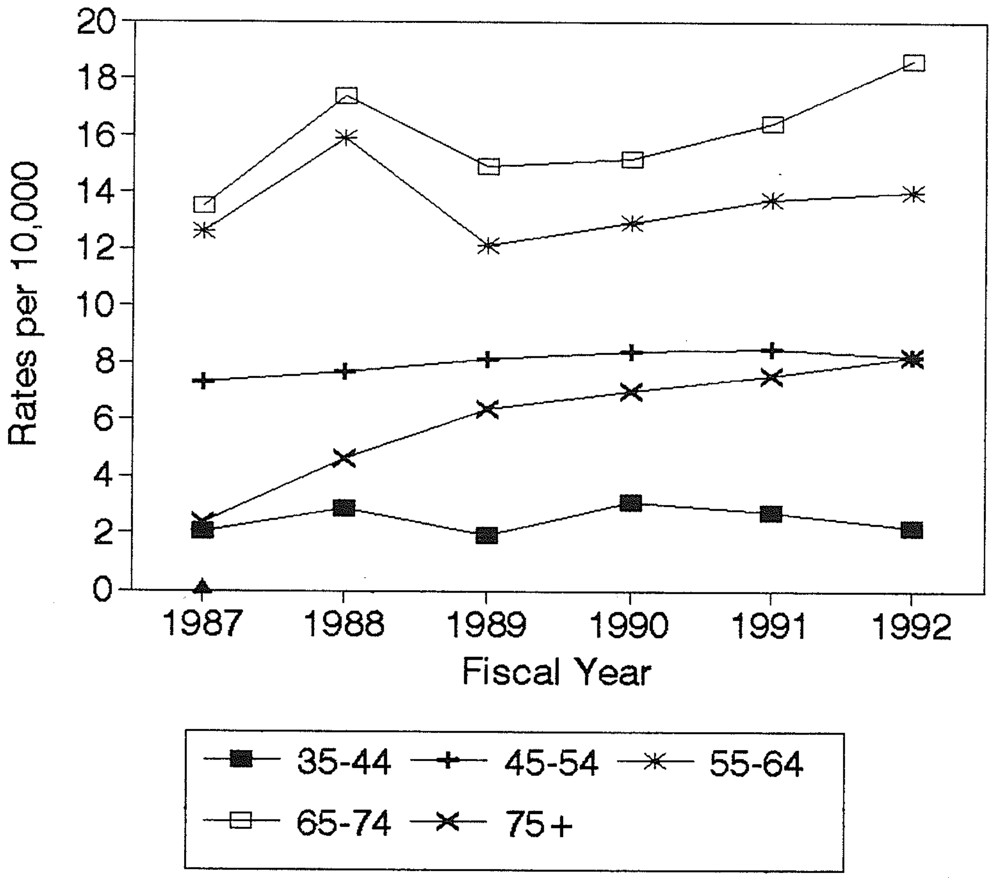

Figure 24. Annual age-specific provincial PTCA utilization rates per 10,000

Age-Adjusted Regional Rates. To examine whether adjusting the rates for differences in the underlying age distribution in the province makes a difference in the regional rates, the age-specific rates were standardized. The unadjusted and adjusted angiography rates are compared in Figure 25. The adjusted rates indicate that the age distribution in the regions is basically the same as that in the province as a whole. Thus procedural rate differences in the regions are not explained by regional differences in age distribution.

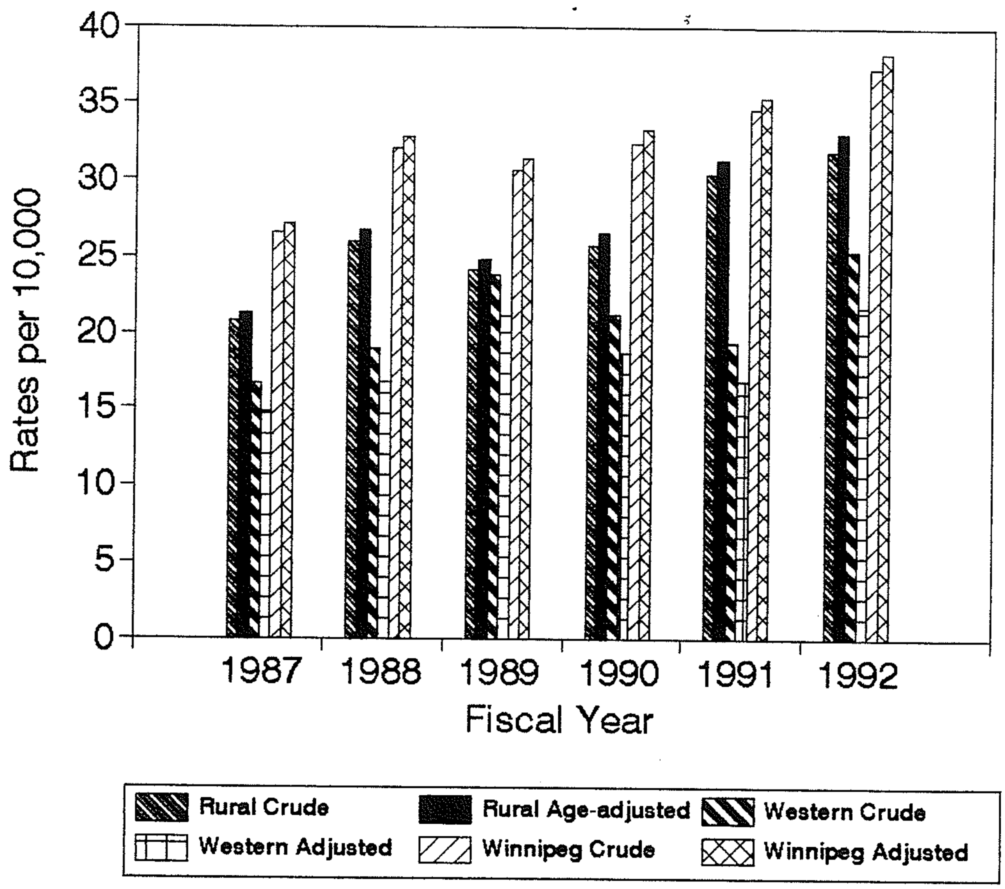

Figure 25. Crude & age-adjusted annual angiography regional rates per 10,000

Gender

Sex-Specific Provincial Rates. Annual, sex-specific procedural utilization rates are displayed in Figure 26. In 1987/88, the angiography rate was twice (2.1) as high in men as in women and although the rate increased gradually in both sexes, the difference remained nearly constant over the six years. Between 1987/88 and 1992/93, the rate in men (40.8%) grew more slowly than in women (53.2%).

The gender difference in annual rates widened for CABS. Over a threefold difference in rates (3.3) was found between men and women although there was modest growth in the utilization rate over the six years. Between 1987/88 and 1992/93, the CABS rate for men (18.7%) increased more rapidly than in women (9.1%). For PTCA there was over a two-fold (2.4) gender difference in utilization; however the rate in women grew more quickly (50%) between 1987/88 and 1992/93 than in men (17.7%).

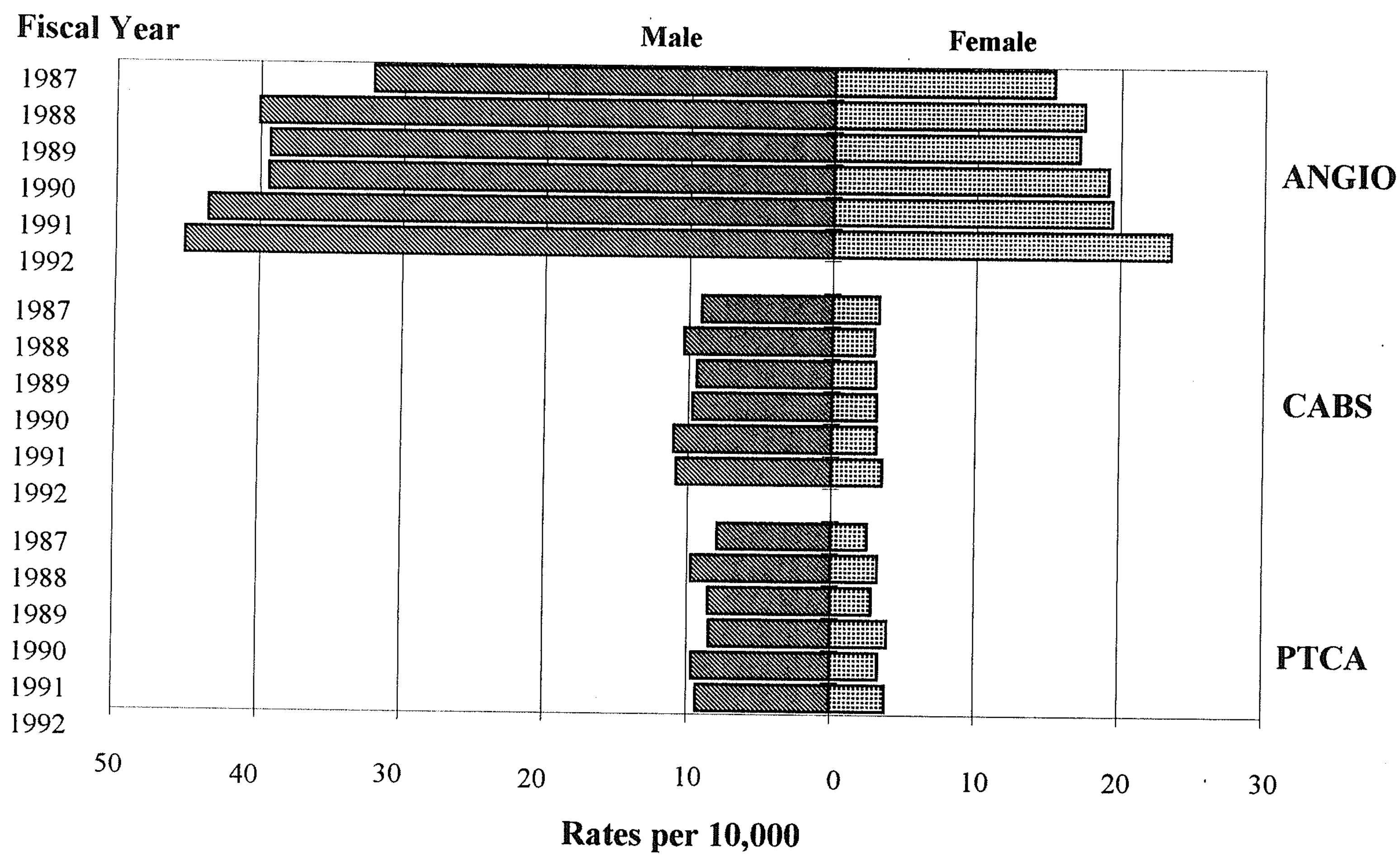

Figure 26. Annual sex-specific provincial rates for angiography, CABS & PTCA

Sex-Adjusted Regional Rates. To determine whether adjusting for differences in the underlying gender distribution in the province affects regional rates, the regional rates were standardized and the PTCA unadjusted and adjusted regional rates are compared in Figure 27. No discernable effect of gender was detected indicating that the gender distribution of the population in the regions did not differ from the provincial population. Thus regional differences in procedural rates are not explained by regional differences in gender distribution.

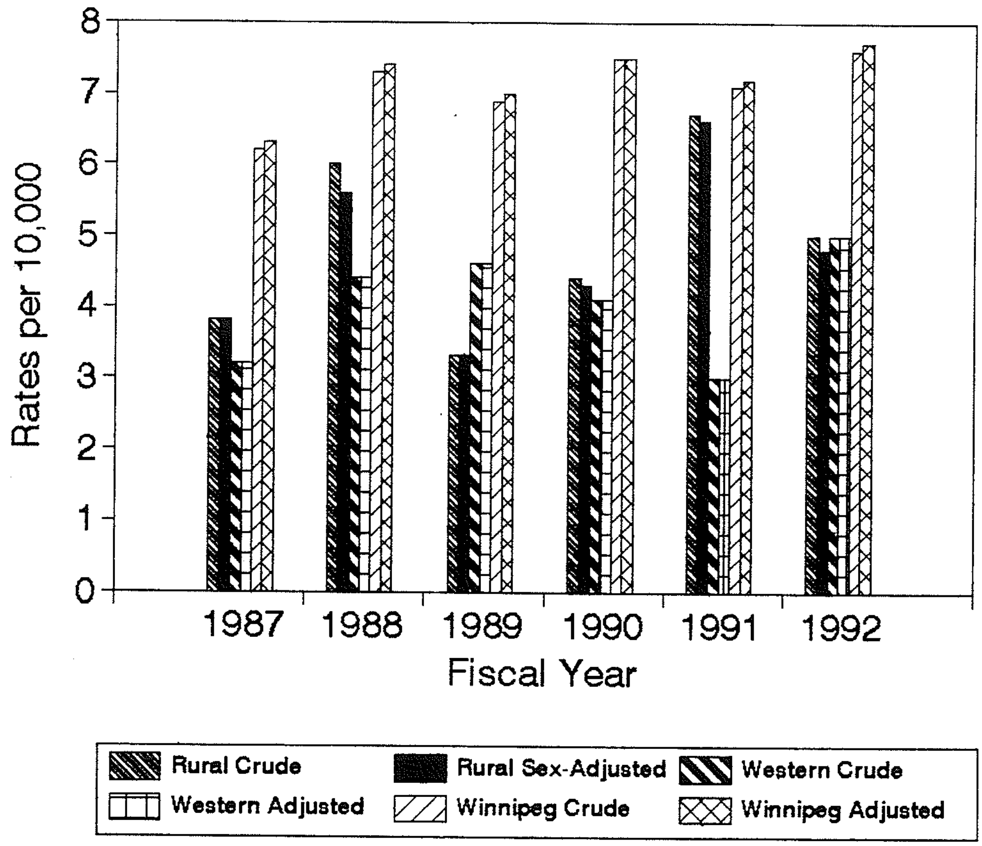

Figure 27. Crude & sex-adjusted annual PTCA regional rates per 10,000

Income

Income-Specific Provincial Rates. The availability of Statistics Canada's income census tapes enabled the issue of equity to be examined. Using income quintiles in which Quintile 1 is the least affluent income and quintile 5 is the most affluent, Figure 28 displays the annual, income-specific, provincial angiography rates across quintiles. Between 1987/88 and 1992/93, the rates increased in all quintiles although annual fluctuations occurred. Except for the years 1991/92 and 1992/93, Quintile 1 had the lowest angiography utilization rates of all the quintiles.

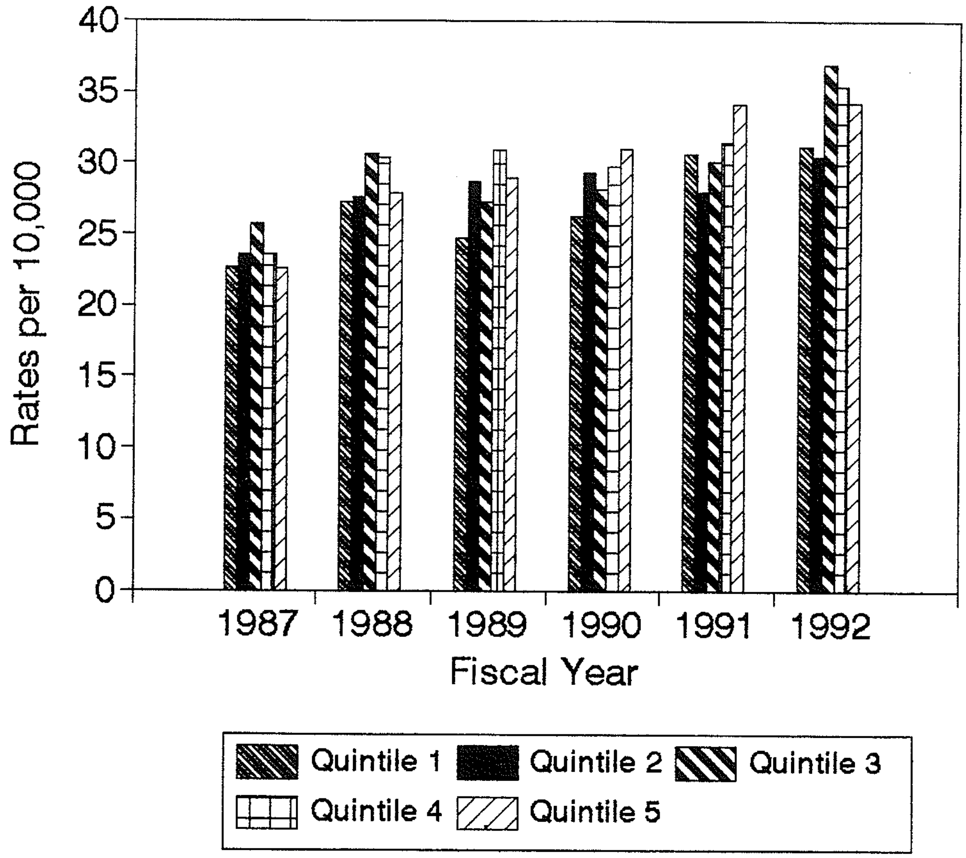

Figure 28. Annual income-specific provincial angiography utilization rates

Annual income-specific provincial CABS rates are displayed in Figure 29. Although there are annual fluctuations in all quintiles, between 1987/88 and 1992/93, rates increased in all quintiles except quintile 2 where they decreased by 13.7%. Quintile 1 had the lowest utilization rates in all years except 1988/89 and 1991/92.

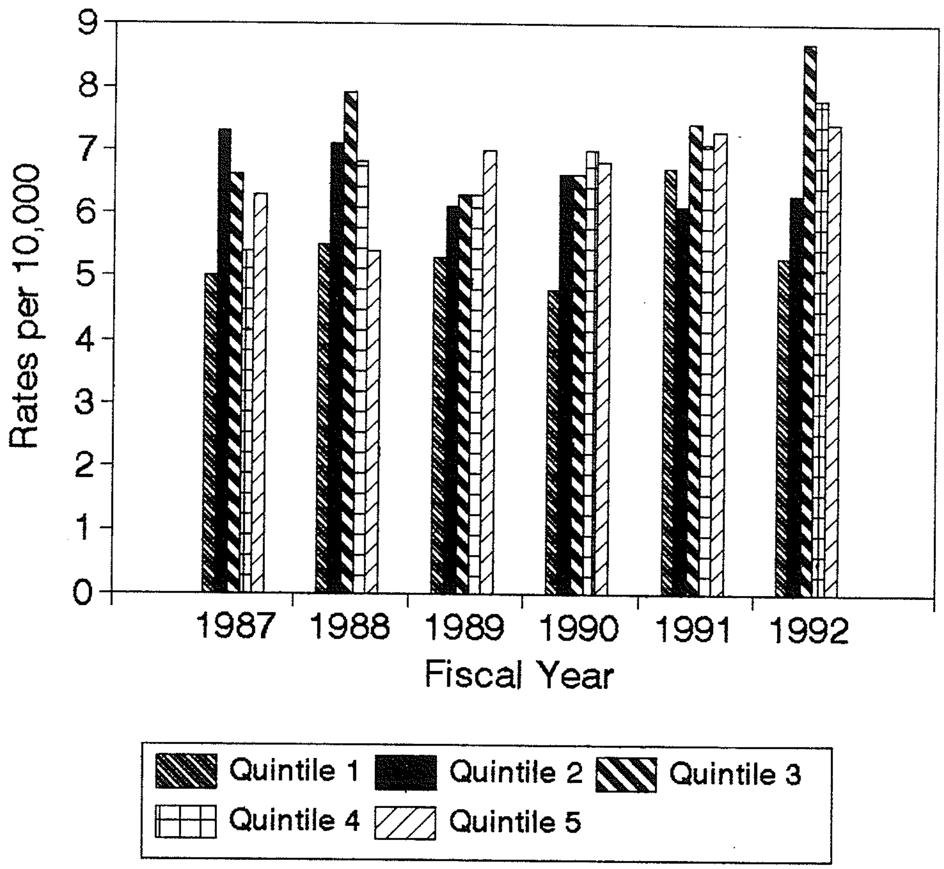

Figure 29. Annual income-specific provincial CABS utilization rates

Examining annual income-specific provincial PTCA rates, Figure 30 displays that between 1987/88 and 1992/93, there was an increase in rates in all quintiles although quintile 2 had the lowest increase at 4.2%. In 1987/88 and 1990/91, the lowest PTCA utilization rates occurred in Quintile 1, while in 1989/90, 1991/92 and 1992/93, the lowest utilization rates were in Quintile 2. In 1987/88, 1990/91 and 1991/92, the highest PTCA utilization occurred in Quintile 5; no pattern emerged in the other years.

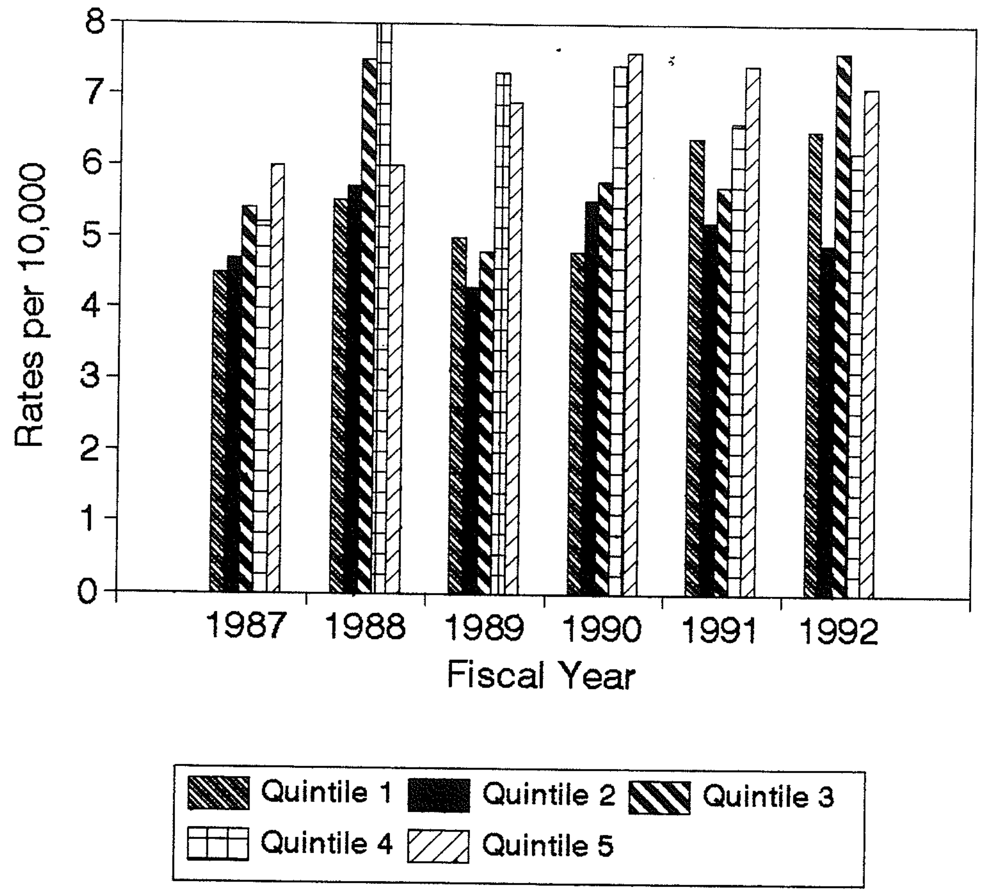

Figure 30. Annual income-specific provincial PTCA utilization rates

Income-Adjusted Regional Rates. To examine whether adjusting the regional rates for differences in the underlying income distribution in the region, the rates were standardized and the CABS rates are compared in Figure 31. Regional procedural rate differences in the regions are not explained by differences in the income distribution between regions.

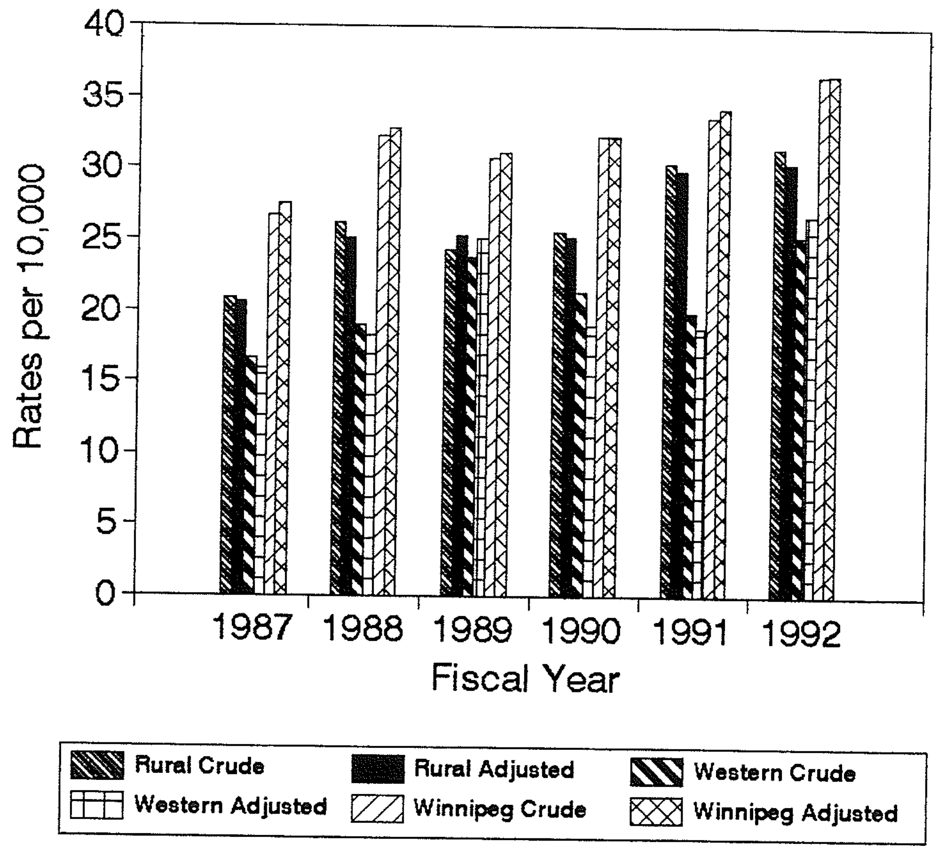

Figure 31. Crude & income-adjusted annual angiography regional rates

Region

Focusing now on regional variation, Figure 32 displays that the Western Region consistently had the lowest mean unadjusted rates for all procedures, followed by the Rural Region, with Winnipeg having the highest rates. Over the course of the study period, Winnipeg's angiography rates were 35% higher than the Western Region and 18% higher than the Rural Region. For CABS, the Winnipeg rates were 27.3% higher than the Western Region and 19.9% higher than the Rural Region. For PTCA, the Winnipeg rates were 42% higher than the Western Region and 32% higher than the Rural Region. Since there is no reason to believe that IHD differs across regions since the earlier study (Roos & Sharp, 1989) these rates indicate that regional differences in access/referral to CAD procedures still occurs.

It has already been demonstrated that regional unadjusted rates are unaffected by age, sex or income-adjustment and Table 41 summarizes these findings.

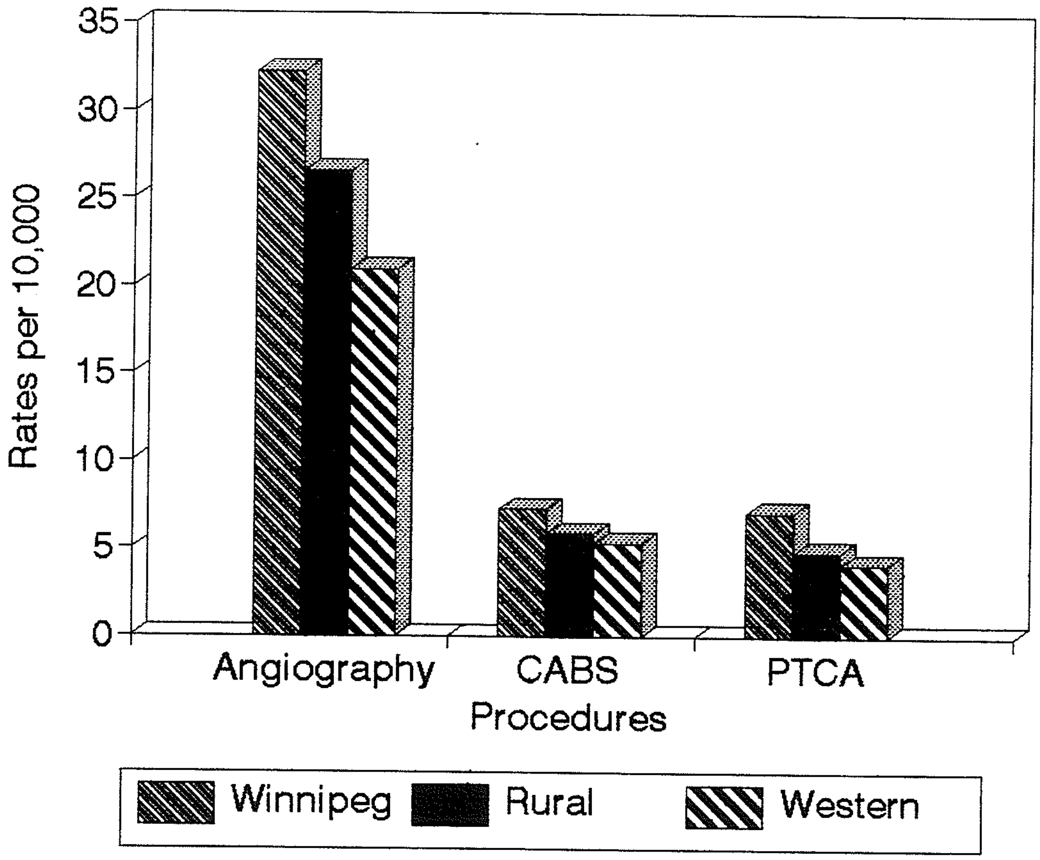

Figure 32. Unadjusted mean regional utilization rates per 10,000

Table 41

Comparison of Regional Mean Unadjusted and Age, Sex and Income-Adjusted Angiography, CABS and PTCA Rates per 10,000 Population

	Rates			
	Unadjusted	Age-Adjusted	Sex-Adjusted	Income-Adjusted
		Angiography		
Rural Region	26.5	27.3	26.1	26.1
Western Region	20.9	18.3	20.8	20.6
Winnipeg	32.2	33.1	32.5	32.4
		CABS		
Rural Region	5.8	6.1	5.7	5.6
Western Region	5.3	4.5	5.2	5.2
Winnipeg	7.2	7.4	7.3	7.2
		PTCA		
Rural Region	4.8	5.1	4.7	5.0
Western Region	4.1	3.5	4.1	3.9
Winnipeg	7.1	7.3	7.2	7.0

Examining regional time trends, the annual regional age-adjusted angiography rates were significantly different in every year between Winnipeg (with the highest rates) and the Western Region (with the lowest rates, $p < .0001$). Similarly, annual age-adjusted differences between Winnipeg (with the highest rates) and the Western Region (with the lowest rates) were found for every year ($p < .004$) except 1989/90 ($p < 0.0551$). Annual regional age-adjusted PTCA rates were significantly different in every year ($p < 0.0001$) with Winnipeg having the highest rates but the lowest rates fluctuated between the other two regions over the years (Figure 33).

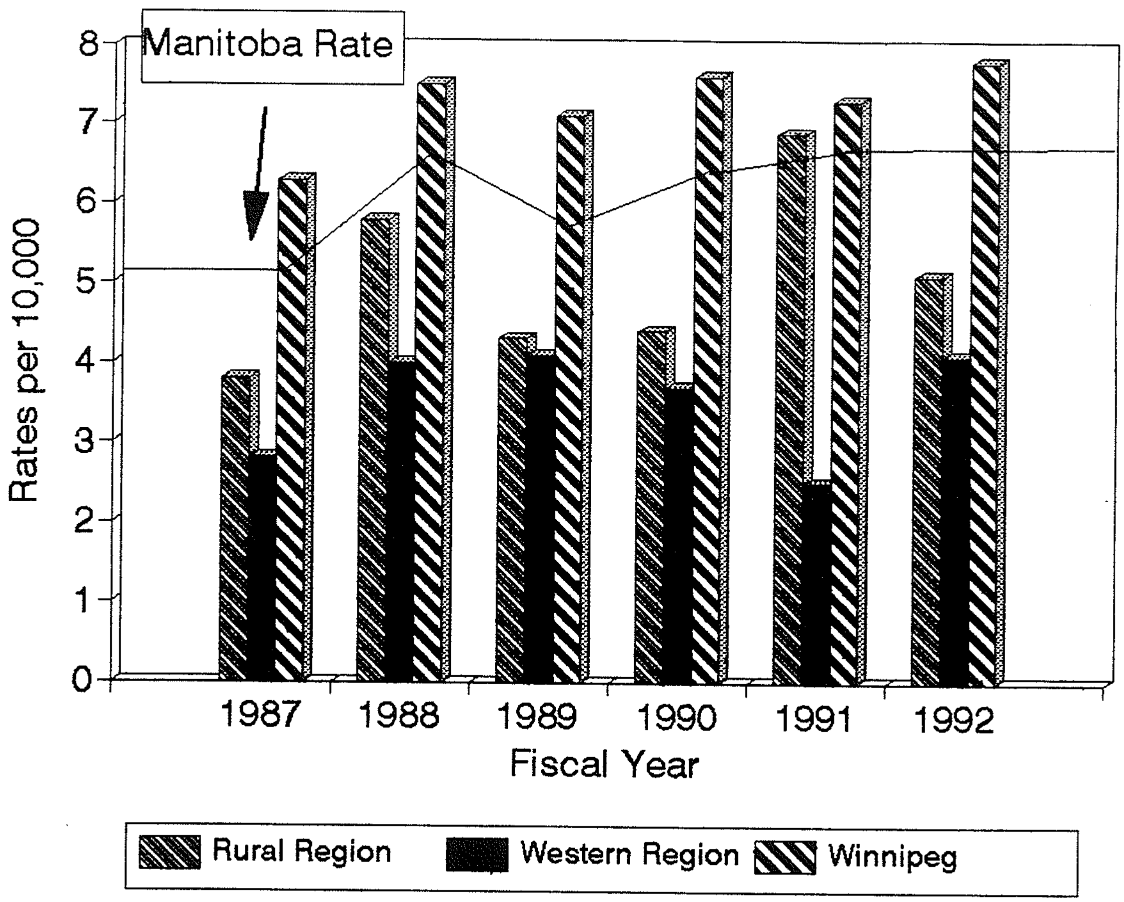

Figure 33. Age-adjusted regional PTCA rates per 10,000 (FY 1987-1992)

Differences in sex-adjusted regional angiography rates occurred between Winnipeg and the Western Region in every year ($p < .0001$) and in PTCA rates between Winnipeg and the Western Region in every year ($p < .0008$) except 1989/90 and 1992/93 when the Other Rural Region had the lowest rates ($p < .0001$). In all but two years, 1989/90 ($p < .1195$) and 1992/93 ($p < .1932$), significant differences in sex-adjusted CABS rates between Winnipeg (with the highest rates) and the Western Region (with the lowest rates) were found (Figure 34).

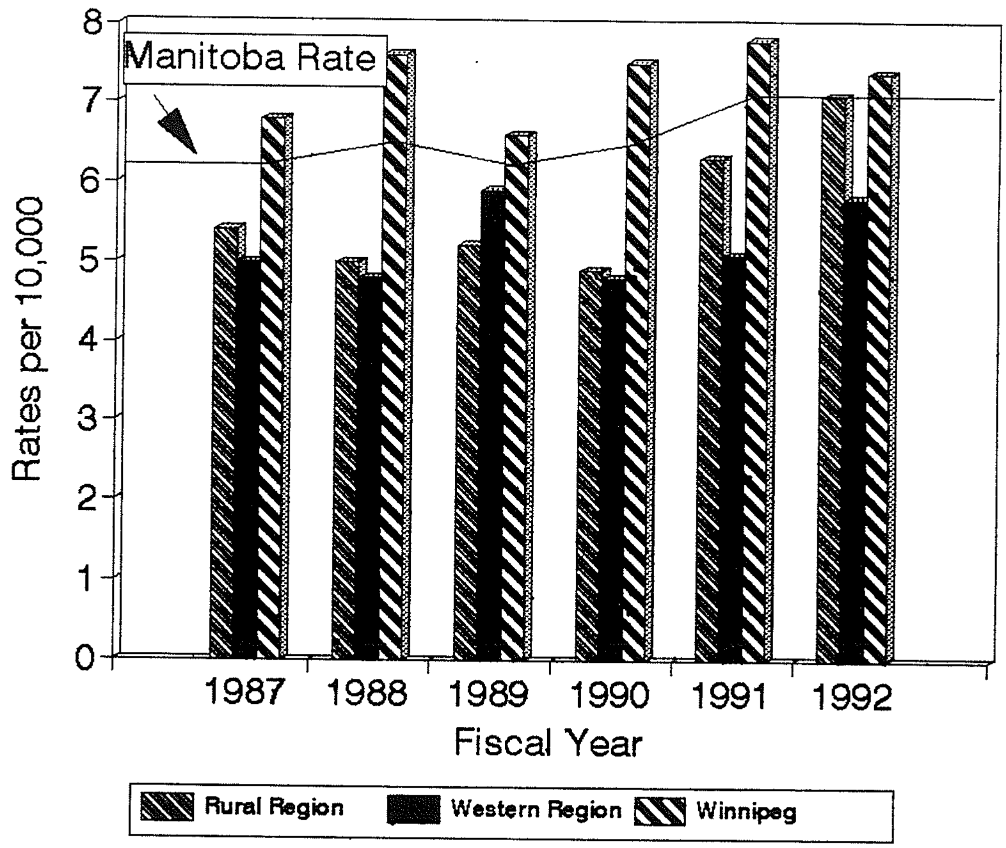

Figure 34. Sex-adjusted regional CABS rates per 10,000 (FY 1987-1992)

Examining annual income-adjusted regional angiography rates, a statistically significant difference in rates between Winnipeg (with the highest rates) and the Western Region (with the lowest rates) occurred in every year ($p < .0001$). In contrast, a significant difference in the income-adjusted, regional CABS utilization rates between Winnipeg and the Western Region occurred in every year except in 1989/90 ($p < .3399$) and 1992/93 ($p < .5606$). Income-adjusted regional PTCA rates were highest in Winnipeg and lowest in the Western Region (Figure 35) except in 1989/90 and 1992/93 when the Other Rural Region had the lowest rates ($p < .0007$).

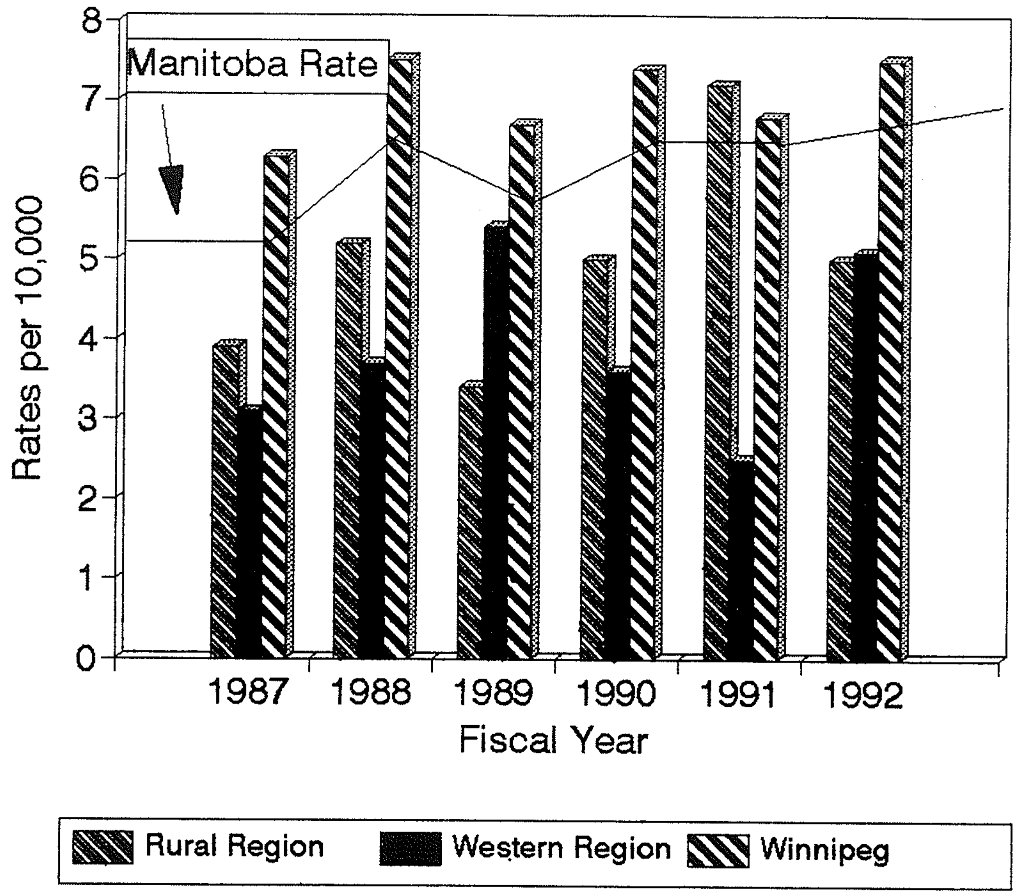

Figure 35. Income-adjusted regional PTCA rates per 10,000 (FY 1987-1992)

Case Fatality

Thirty day case fatality rates are a conventional method of assessing operative/procedural mortality. To calculate case fatality rates, the number of deaths occurring in a specified time interval is divided by the population at risk, that is, the number of patients having the procedure. Case fatality is typically expressed as a percentage. Angiography case fatality rates were not calculated because they are uninformative; it is not known whether patients died because they were too ill to benefit from CABS or PTCA or whether they had a CABS or PTCA within 30 days of angiography and subsequently died.

Coronary Artery Bypass Surgery

From 1987/88 to 1992/93, the mean CABS 30 day case fatality rate for Manitoba was 5.5% and the one year case fatality rate was 7.4%. Wide variations in annual, regional, case fatality rates were found (Figure 36). It is likely that the fluctuations were related to the small number of deaths occurring in each region over the six years. Over the study period, there were only 155 deaths within 30 days of CABS and within one year there were 208 deaths, an additional 53 deaths. The highest rate occurred in 1989/90 in the Rural Region; the one year case fatality rate was 13.9% and represented 14 deaths. No differences in annual 30 day or one year case fatality rates were found among the regions. Because of the small number of deaths occurring in each region annually, the years were collapsed into two intervals: (a) 1987/88-1989/90, and (b) 1990/91-1992/93. Using these two time intervals, no significant differences in the 30 day case fatality between the highest and lowest region were found; for one year case fatality, there was a significant difference between the Rural Region (with the highest case fatality rate) and Winnipeg (with the lowest case fatality rates) for the interval 1987/88-89/90 ($p < .0058$) and 1990/91-1992/93 ($p < .0394$).

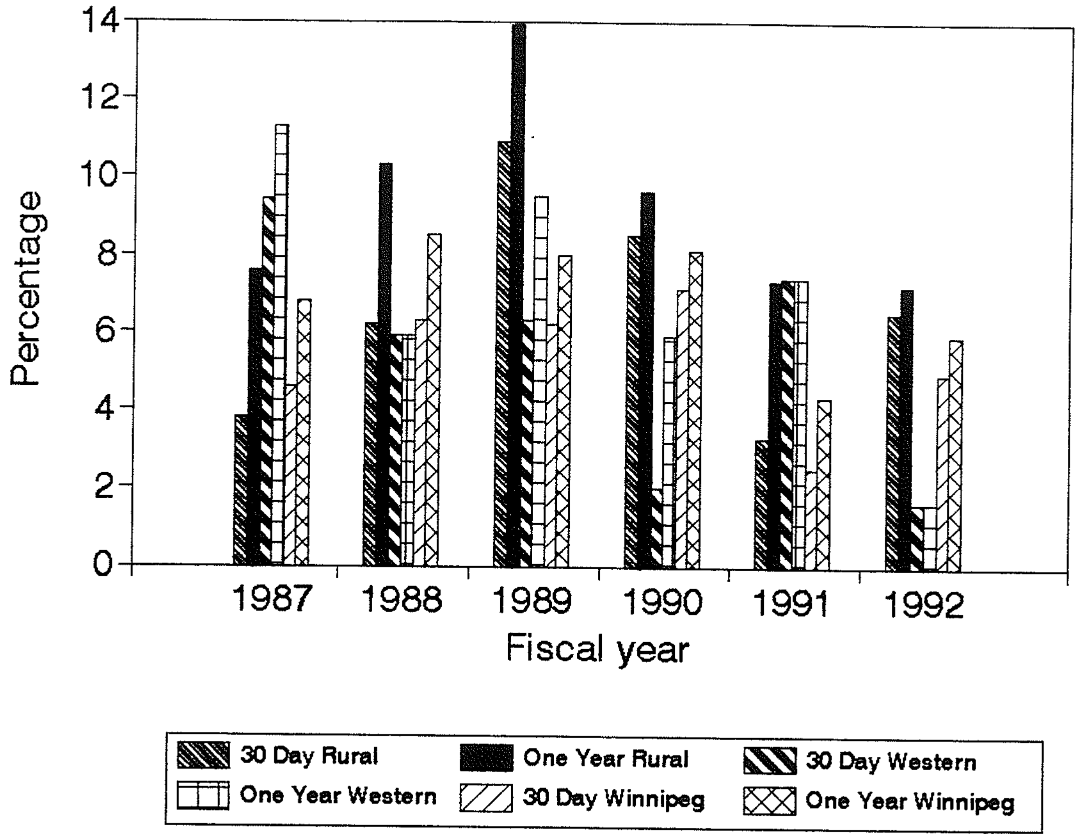

Figure 36. Annual regional 30 day & one year CABS case fatality rates

Differences in regional 30 day and one year mean case fatality rates were examined because they may be an indication that patients from different regions present and/or are referred for CABS with differing severity of CAD (Figure 37). The Rural Region had the highest 30 day mean CABS case fatality rate over the course of the study at 6.4%, followed by the Western Region at 5.4% and Winnipeg at 5.3%. The Rural Regions' 30 day mean CABS case fatality rates were 18.5% higher than the Western Region and 20.8% higher than Winnipeg. The magnitude of the difference between the Rural Regions' CABS case fatality rates widened between 30 days and one year. Looking at the one year case fatality rates we find that the Rural Region had the highest rate at 9.1%, followed by Winnipeg and the Western Region at 6.9%. The Rural Region's one year rates were 31.9% higher than the Western Region and Winnipeg.

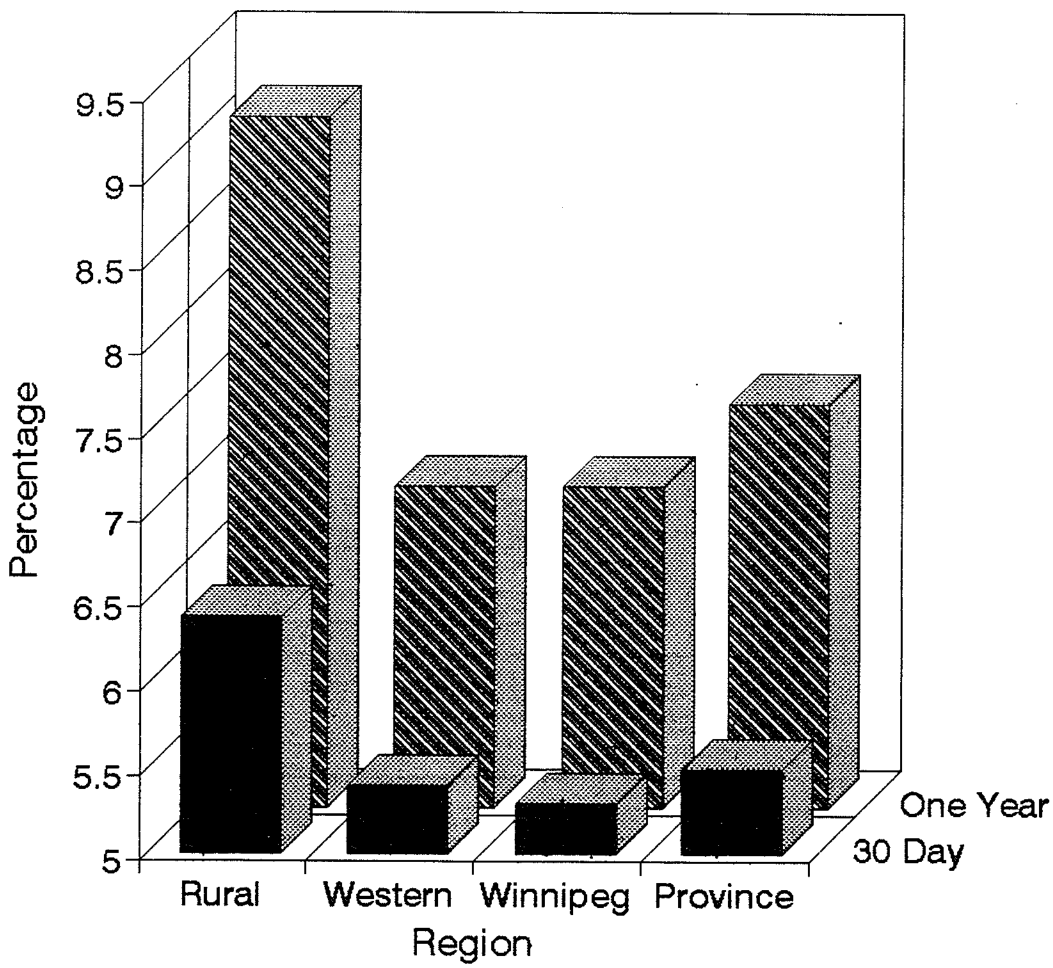

Figure 37. Regional & provincial 30 day & one year CABS case fatality

Percutaneous Transluminal Coronary Angioplasty

The mean PTCA 30 day case fatality rate for Manitoba during 1987/88 to 1992/93 was 2.1% and the one year case fatality rate was 3.8%. Wide variation in annual rates was found (Figure 38). Undoubtedly these fluctuations were related to the small number of deaths occurring within 30 days (n = 55) and one year (n = 99) over the six years. Because of the small number of deaths in each region annually, the years were collapsed into two intervals: (a) 1987/88-1989/90, and (b) 1990/91-1992/93. Using these two time intervals, no significant differences in the 30 day or one year case fatality rates between the regions were found.

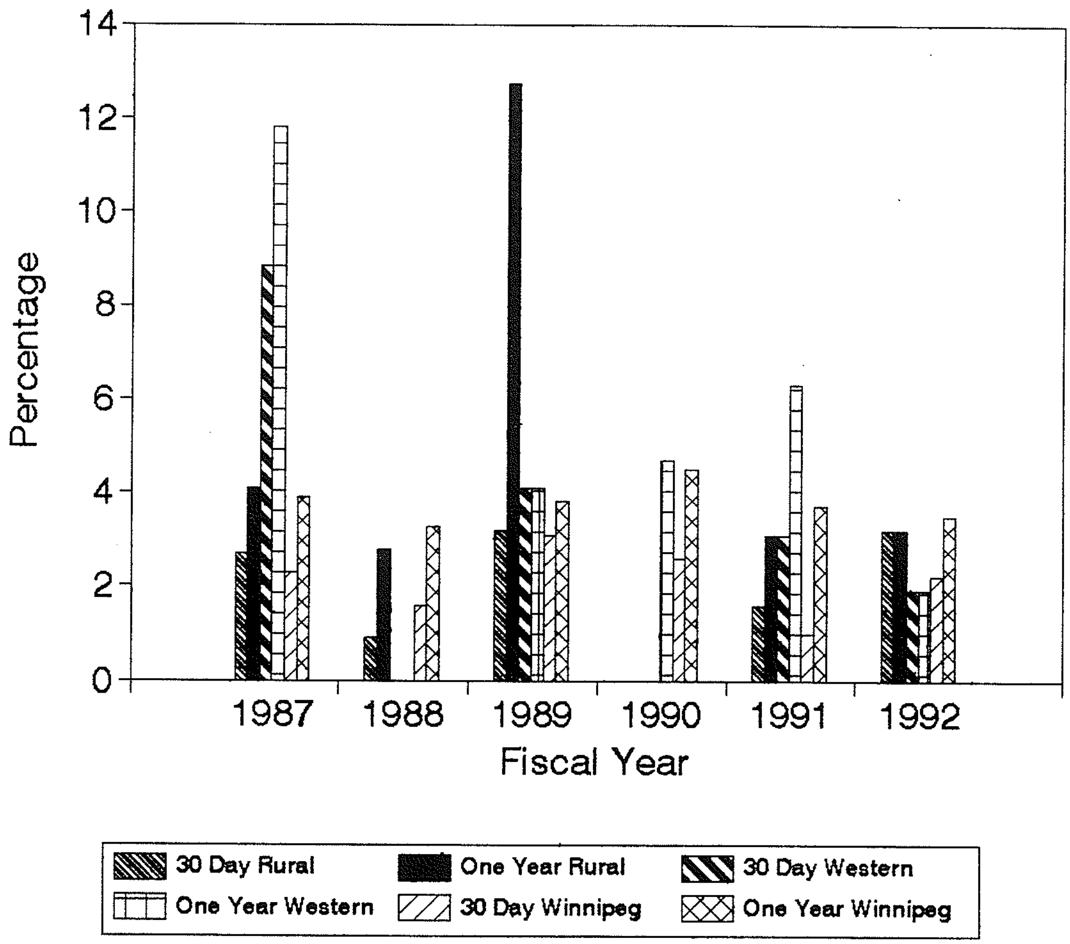

Figure 38. Annual regional 30 day & one year PTCA case fatality rates

Turning now to an examination of mean regional rates, the 30 day and one year PTCA case fatality rates were compared (Figure 39). The 30 day rates were highest in the Western Region at 2.7%, followed by Winnipeg at 2.1% and lastly the Rural Region at 1.8%. The Western Region's 30 day rates were 50% higher than the Rural Region and 28.6% higher than Winnipeg. The one year rates were also highest in the Western Region at 4.3%, followed by the Rural Region and Winnipeg at 3.8%. The Western Regions's one year case fatality rates were 13.1% higher than the Rural Region and Winnipeg.

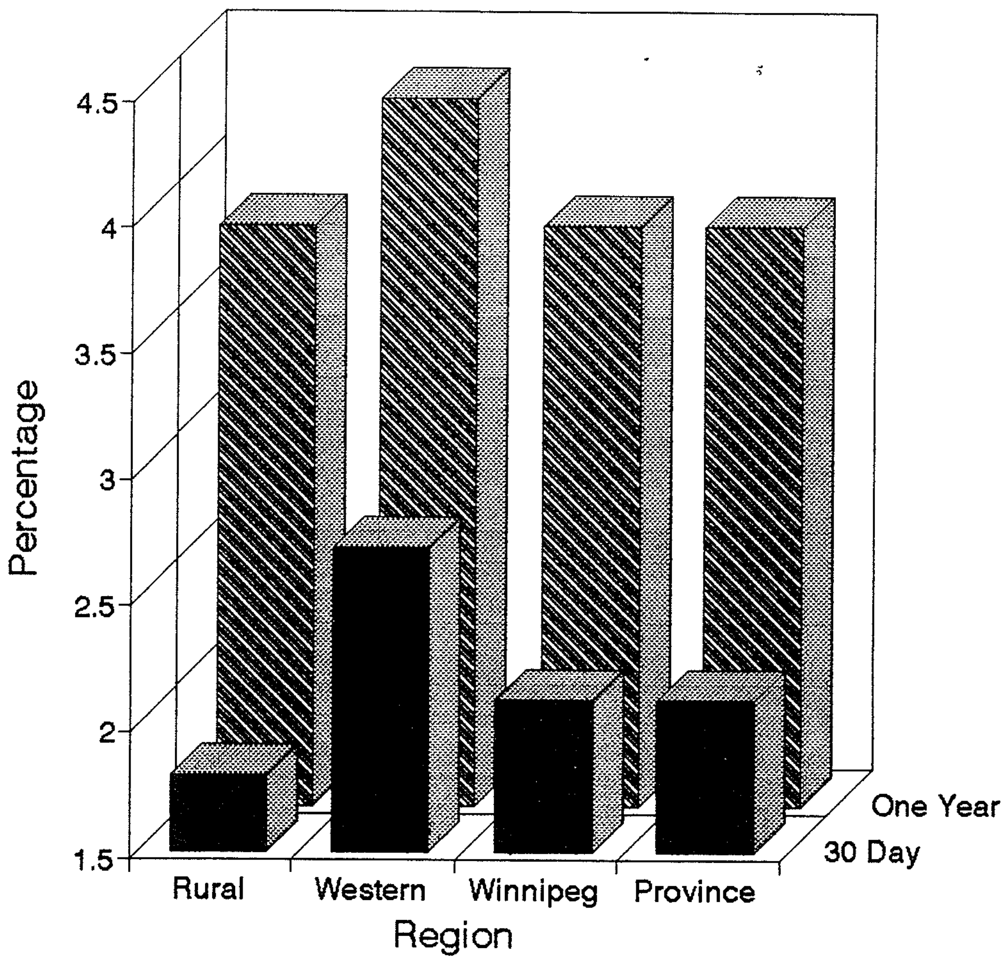

Figure 39. Regional & provincial 30 day and one year PTCA case fatality

Probability of Events

The probability of Manitoba residents aged 25 and older having angiography was .017. Men have twice the probability (.024) of women (.0112) of having angiography. Having had angiography, the probability of proceeding to CABS over the course of the study was only slightly (.011) greater than to PTCA. Having had angiography, the probability proceeding of men proceeding to CABS was greater (.2505) than women (.1728). Similarly the probability of men proceeding to PTCA was greater (.239) than women (.179). In the absence of diagnostic information, these probabilities are difficult to interpret.

Discussion

Trends In Utilization

Angiography rates grew by almost 50% in Manitoba over the six years of the study, while CABS rates grew by 20% and PTCA rates by 30%. The stronger growth in angiography is due to several factors. The growth reflects an increased demand and the ability of the health care system to respond to the demand. In contrast to CABS and PTCA, angiography rates can rise more easily since cardiac catheterization labs can book additional cases and/or work overtime. On the other hand, the more stable growth in CABS and PTCA may reflect a supply constraint; expansion, if needed, can only occur through increased supply, e.g. increased access to operating room theatres, intensive care beds and/or physician and other health personnel human resources.

A previous study reported a mean annual Manitoba angiography rate between 1979/80 and 1984/85 of 10.3 per 10,000 population aged 25 and over (Roos & Sharp,

1989) whereas in this study between 1987/88 and 1992/93, the mean annual rate was 29, a 181% increase. A second factor responsible for this increased use is the greater acceptance of the value of the procedure on the part of both physicians and patients and a more aggressive approach to CAD. Increased use of other non-invasive diagnostic tests such as exercise testing, echocardiography, etc. has also been credited with leading to increased utilization of angiography (Naylor, Ugnat, Weinkauf, Anderson & Wieglosz, 1992). Table 42 displays Manitoba's angiography, CABS and PTCA rates with other Canadian jurisdictions and although the rates are for different years Manitoba's rates appear similar.

Table 42

Comparison of Manitoba Rates per 10,000 with Other Canadian Jurisdictions

	Procedure		
	Angiography	CABS	PTCA
Manitoba	10.3[a]	4.7[a]	
	29[b]	6.5[b]	6.1[b]
Ontario		7.4[c]	6.6[d]
Canada		4.7[e]	

Note. [a] Roos and Sharp, 1989, 1979-1984 mean rate.
[b] Hartford, 1996, 1989-1992 mean rate.
[c] Naylor et al. 1994, 1991/92 rate.
[d] Ugnat & Naylor, 1993, 1989/90 rate.
[e] Gentlemen et al. 1994, 1990/91 rate.

During the course of this study CABS rates grew by 20%. Roos and Sharp (1989) noted that between 1979/80 and 1984/85 the mean annual provincial rate of CABS was 4.7 per 10,000, while this study found a rate of 6.5 per 10,000, a 38.3% increase since 1979/80. The modest rate of growth of CABS in Manitoba is thought to be unrelated to a decrease in the incidence of CAD, since between 1981/82 and 1986/87 there was a 22.6% increase in the number of hospitalizations for IHD in 12 census metropolitan areas in Canada (Peters et al. 1990). It is likely that the levelling off of CABS rates is related to both a capping policy by government and a "skimming" of younger patients with limited CAD for PTCA (Naylor et al. 1992).

Manitoba's growth in CABS rates is similar to other jurisdictions, although variation between jurisdictions exists. In Ontario between 1983/84 and 1986/87, CABS rates were relatively stable at 4.1 per 10,000 (Naylor et al. 1992) By 1991/92, the Ontario rate grew to 7.4 per 10,000, an 80% increase (Naylor, Anderson & Goel, 1994). Wide variation in age-specific CABS rates in the 12 census metropolitan areas was found in 1986/87; rates ranged from a low of 1.9 per 10,000 in Saskatoon to a high of 4.7 in Montreal. Edmonton was noted as having one of the lowest CABS rates (2.4 per 10,000) and concern was expressed about underutilization. A study of all CABS in Alberta between FY 1984/85 and 1989/90 found that overall there was a slight increase in the rate to 2.9 per 10,000, but that the rate did not vary significantly between men and women across Alberta's nineteen census subdivisions (Platt et al. 1993). Nationally, the Canadian rate in 1986/87 was 4.3 per 10,000 (Peters et al. 1990) and by 1990/91, the rate grew to 4.7 per 10,000, a 9% increase (Gentleman, Parsons, Walsh & Vayda, 1994). It should be noted that between 1986/87 and 1987/88 the number of CABS increased by 45% in the United States (Leape et al. 1991). Inter-country variations can be seen in the 1985 European rates; rates varied from a high of 4.9 per 10,000 in the Netherlands to a low of 0.3 in Hungary (Naylor et al. 1992).

Naylor and colleagues (1992) conducted a review of CABS reports in Canada in an attempt to determine the "right rate". Because rates varied at the provincial level, they were not surprised to find small area variations. Although reasons for the growth in CABS rates were postulated, appropriateness studies were recommended; such studies go beyond the scope of administrative data.

While no previous Manitoba data on PTCA were available, the mean annual provincial utilization rate in this study was 6.1 per 10,000. The rate increased from 5.1 in 1987/88 to 6.5 in 1992/93, a 27% increase. In Ontario, the PTCA rate was 6.4 per 10,000 in 1987/88, as compared to 6.6 in 1989/90, a 3% increase (Ugnat & Naylor, 1993). In the U.S., the number of PTCA procedures doubled between 1988/89 and 1990/91. In 1988/89, the number of PTCA performed in the U.S. was the same as the number of CABS, but by 1990/91 PTCA exceeded CABS (Hilborne et al. 1991). The growth in PTCA in Manitoba without a concomitant decrease in CABS, reflects what is occurring in other jurisdictions. If, as originally expected, PTCA were a substitute procedure for single vessel CABS, one would have expected to see a drop in CABS as PTCA was introduced. When no decrease in CABS occurred, overutilization of CABS or a tremendous backup of cases was speculated. Now it is thought that the indications for both procedures have changed and this is supported by the literature which reports that PTCA is used for single, double and more recently, for triple vessel disease while CABS is used for triple vessel disease and left main disease; utilization of both procedures has grown in the elderly (Hilborne et al. 1991). While this study cannot address the appropriate indications for CABS or PTCA, the administrative database is particularly well suited to the examination of age-specific utilization rates.

Age-Specific Utilization

Population growth is not directly related to growth in angiography in Manitoba. While the population of Manitoba has grown only slightly (4.9%) from December 1, 1982 to December 1, 1992, the 75 and older age group has increased by 30.6% (Manitoba Health 1982-83, 1992-93). However, increases in angiography utilization occurred in all age groups. In a study of a random selection of patients in New York and Ontario and British Columbia, a higher percentage of angiograms was performed on patients aged 75 and older in New York than in either Ontario or British Columbia (McGlynn et al. 1994).

Turning now to age-specific utilization rates of CABS, between 1987/88 and 1992/93, Manitoba experienced decreased utilization of CABS in the 25-64 age group, a 28.5% increase in the 65-74 age group and a 105.6% increase in the 75 and older age group. This is in contrast to an earlier Manitoba study which noted growth in rates in all age groups, with the largest growth occurring in the elderly (Roos & Sharp, 1989). Decrease in CABS growth in the younger age groups is indicative of stabilization that occurs as a technology becomes accepted and also increased utilization of PTCA is thought to be reflective of the decrease in CABS in this age group. Manitoba's increased utilization in the elderly mirrors that occurring in other jurisdictions. Between 1981/82 and 1991/92 in Ontario, the fastest rate of growth in CABS occurred in patients aged 65 and over; the age-specific rate for Ontario men aged 65 and older rose from 9.9 to 33.5 per 10,000, while for women it rose from 2.9 to 9.5 per 10,000 (Naylor et al. 1994). In Canada between FY 1981/82 and 1985/86, there was a 1.8 fold increase in CABS rates in the 65-74 age group and a 2.7 fold increase in the 75 and over age group (Anderson et al. 1989). Two observational studies found that a significantly higher percentage of patients 75 years and older had CABS in U.S. states than in Canadian provinces (Anderson et al. 1993; McGlynn et al. 1994).

From 1987/88 to 1992/93, PTCA rates in Manitoba decreased in the 25-34 age group and increased in all other age groups with the largest rates of growth occurring in those 75 and over. While no RCTs of PTCA in the elderly have been reported, a review of nine observational studies involving over 3000 patients aged 65 and over, have established the long-term efficacy of the procedure in the elderly (Johansson, Brorsson & Bernstein, 1994).

No regional differences in crude and age-adjusted rates in the three procedures were found. In summary, Manitoba reflects other jurisdictions' experiences in that the elderly have increased utilization of CAD procedures due to a more aggressive approach to CAD, improvements in technology leading to better outcomes, changing demographics, and a decreased incidence of CAD in the young. The survival analyses conducted in the earlier chapters examined the effect of age on survival and also the interaction between age and other covariates such as gender and income on survival.

Gender Specific Utilization

Men had twice the rate of angiography of women and between 1987/88 and 1992/93 there was a moderate rate of growth in both sexes. Men had over three times the rate of CABS as women; between the first and final year of the study the rates grew slightly in both sexes. For PTCA, the gender differential more closely reflected that of angiography, with men having over twice the rate of PTCA of women. Between 1987/88 and 1992/93, the PTCA rates grew faster in women than in men. With angiography serving as a funnel to CABS and PTCA, the rate of angiography should be reflected in the rate for the other procedures. The funnel effect is supported by the fact that the probability of men having angiography, CABS and PTCA was twice that of women.

Although the database used in this study can document the magnitude of the gender differences in utilization of CAD procedures, gender bias cannot be directly attributed to CABS or PTCA without knowing the gender-specific results of angiography. If it were known that the same proportion of men and women were diagnosed with left main disease at angiography and the longitudinal follow-up identified that men were more likely than women to be referred for CABS, there would be an empirical basis for stating that a gender bias in access to CABS existed.

Since angiography serves as a screening procedure for CABS and PTCA, the results of this Manitoba study suggest that a gender barrier may be operating at the angiography entry level, or even prior in the referral chain. These findings are supported by recent Ontario studies in which gender-related differences in referral for revascularization were found. While not examining population-based rates, these studies had information on either the extent of CAD or a proxy measure (acute myocardial infarction). Men with less severe CAD were referred more often than women with more severe CAD for CABS (Naylor & Levinton, 1993). Jaglal and colleagues (1994) studied all Ontario patients with a confirmed diagnosis of AMI between April 1 and September 30, 1990 and followed patients until March 31, 1991 to determine the gender differences in the use of invasive coronary procedures (Jaglal, Goel & Naylor, 1994). For men, unadjusted odds ratio (O.R.) for angiography was 2.2 (95% CI, 1.9 to 2.4), for CABS, O.R. = 2.0 (95% CI, 1.6 to 2.6) and for PTCA, O.R. = 1.9 (95% CI, 1.5 to 2.5). Jaglal's results are in the same direction as eight other studies supporting the interpretation that the magnitude in gender differences is likely related to selection differences and differing thresholds for invasive intervention.

Since women do not present with classic CAD symptoms, physicians may have a higher threshold for referring women for angiography or non-invasive testing. Jaglal, Slaughter, Baigrie, Morgan and Naylor (1995) conducted a chart audit of patients with new CAD who were referred to cardiologists. Primary care physicians were less likely to refer women for non-invasive ischemic testing (NIIT). Among patients who had a prior positive NIIT, cardiologists were more likely to refer women for repeat NIIT. Men were more likely to be referred for angiography, and it was speculated that this difference in management was related to a stronger preference for medical management in women because of earlier studies documenting poorer revascularization outcomes in women.

To summarize, these Manitoba population-based rates documented gender differences in utilization of CAD procedures; these differences were not related to differences in regional gender composition. While these differences are suggestive of gender bias in utilization found in other studies, this cannot be confirmed with the data available. Indeed the gender differences may be appropriate given that men have more coronary artery disease then women. The survival analysis conducted in earlier chapters addressed whether gender differences in referral result in gender differences in survival following CABS or PTCA.

Income-Specific Utilization

Only one previous study examined the effects of income on utilization of CABS services for CAD (Anderson et al. 1993). In the younger age groups, CABS utilization was higher in Manitoba, Ontario and British Columbia in Quintile 1 and was similar across the other four quintiles. In the elderly, the two more affluent quintiles had higher CABS rates, while the three less affluent quintiles had lower, but similar rates. These findings were rather unexpected since if income is not a barrier to health care, one would expect a gradient in CAD utilization that reflects the ischemic heart disease-income relationship (Marmot & Mustard, 1992), that is, increased utilization in the lowest quintile and decreased utilization in the highest.

In examining utilization of services for CAD across income quintiles in Manitoba from 1987/88 to 1992/93, a slight discernable pattern emerges although different quintiles have the highest absolute rates in different years and for different procedures. Yet Figures 28, 29 and 30 display that Quintile 1 has the lowest angiography utilization rates in every year, the lowest CABS utilization rates in four of the six years and the lowest

PTCA utilization rates in three of the six years. No regional differences between income-specific and income-adjusted rates were noted. Thus, in contrast to the distribution of IHD across income quintiles reported in the literature, income-specific utilization of CAD procedures in Manitoba over the six years of the study was not in the expected direction. These results are similar to those found in the elderly in Canada by Anderson and colleagues (1993). These results may reflect the fact that a larger proportion of elderly patients are having CAD procedures in Manitoba and/or may support Anderson's interpretation that the Statistics Canada census data on mean household income are not age-specific. Again, the survival analyses addressed whether the less affluent had higher or lower risks than other income quintiles.

Regional Utilization

A previous Manitoba study (Roos & Sharp, 1989) identified regional disparities in angiography and CABS rates with the Western Region having the lowest rates in the province. Minor regional variations in indicators of IHD were found. Hospitalization for AMI was significantly different across seven regions ($p < .01$) but had a low systematic component of variation, while correlations between AMI hospitalization and AMI mortality rates were not significant across the regions. This study was specifically designed to assess whether that trend continued after dissemination of those findings and found that regional access/referral differences were again sustained over this study period. Overall, the Western Region had the lowest mean, crude utilization rates for all procedures, followed by the Other Rural Region, with Winnipeg having the highest utilization rates. Of importance when examining regional differences is the underlying distribution of the variables of interest in the province as a whole. This study identified that the regional unadjusted rates were not affected by age, sex and income adjustment.

When residents of a region are referred for the screening procedure at lower rates, it should not be a surprise when the same region has lower rates for the therapeutic procedures. This phenomenon is described as a funnel effect: referral for angiography determines subsequent regional differences in CABS and PTCA (Figure 32). For the screening procedure, angiography, Winnipeg's mean rates were 35% higher than the Western Region, and 18% higher than the Rural Region. Conversely, the Western Region's rates were 21.2% lower than the Rural Region and 54.5% lower than Winnipeg. Overall, Winnipeg's mean CABS rates were 27.3% higher than the Western Region and 19.9% higher than the Rural Region. Conversely, the Western Region's rates were 10.2% lower than the Rural Region and 37.5% lower than Winnipeg. Over the course of the study, Winnipeg's PTCA rates were 42% higher than the Western Region and 32% higher than the Rural Region. Conversely, the Western Region's mean PTCA rates were 18.9% lower than the Rural Region and 75.3% lower than Winnipeg.

Thus, lower angiography and CABS utilization rates in Western Manitoba have continued since the earlier study and are now documented for PTCA. Combined with the previous evidence that IHD does not vary across regions, underutilization and regional referral differences can be said to exist in the Western Region. That this underutilization persists with continued discussion in the literature about the effectiveness of CABS and PTCA reinforces Roos' and Sharp's (1989) conclusion that the Western Region's physicians reluctance to refer patients to Winnipeg is responsible for the lower rates. Publications on the effectiveness of the two procedures should have reduced the physician uncertainty about outcomes that is often cited when interpreting small area variations.

This study also found a regional referral disparity existed for Winnipeg, which in every year and for every procedure had the highest utilization rates. This higher rate is likely related to different selection criteria, lower referral thresholds, and propinquity. Although the survival analyses did not identify increased risk of mortality associated with region of residence, the impact of differing regional treatment modalities on CAD and health status could not be determined. The association between utilization and case fatality is discussed later.

In a 1992 publication in which variations in CABS rates in Canada were examined, Naylor and colleagues prioritized a research agenda into the use of CABS in Canada; this agenda could be extended to other CAD procedures. This chapter has addressed two components of that agenda: (a) utilization by age, sex and income, and (b) mortality outcomes associated with CABS and PTCA. Two additional priorities are particularly relevant to, and reinforced by, these findings of regional disparities in CAD procedures. The first priority concerns the need for appropriateness studies. Appropriateness of coronary angiography and CABS in the elderly in one Manitoba hospital has recently been compared to three hospitals in three states using data from the late 1970's and early 1980's (Roos, Bond, Naylor, Chassin & Morris, 1994). Fewer Manitoba angiography and CABS patients were rated as equivocal or inappropriate than in the hospitals in the states. A similar study examining regional patterns within

Manitoba using more recent data could address the issue of regional variation. Inappropriate use does not however always explain geographical variations (Chassin et al. 1987) but needs to be ruled out in the light of no variance in IHD.

The second priority is the role of local practice and referral patterns in generating small area variations. Manitoba is particularly well poised to conduct such studies because the administrative database can be used to identify regional samples of patients who present to physician's offices with symptoms of CAD. A cohort study using chart audit could be conducted to determine whether the regional selection criteria, investigative and referral chains vary and to document the reasons for any variance.

Case Fatality

CABS Case Fatality

The mean CABS 30 day case fatality rate was 5.5% and the one year case fatality rate was 7.4%. In keeping with findings from other studies, Manitoba CABS case fatality exceeded PTCA at both 30 days and one year. In examining differences between short and long-term mortality, Roos, Fisher, Brazaukas, Sharp and Shapiro (1992) examined 30 day, one year and three year mortality rates for CABS, with and without concurrent valve replacement, in patients 65 years of age and older in Manitoba from 1980/81-1986/87. These rates were compared with those in New England during 1984/85 and 1985/86. The mortality rates were higher in Manitoba than in New England at 30 days only; (a) 7.1% versus 6.4% at 30 days, (b) 10.7% versus 12.1% at one year, and (c) 15.4% versus 18.5% at three years. When CABS without concurrent valve replacement was compared, the Manitoba 30 day mortality rates were 5.33% and New

England's were 5.57%, while the one year rates were 8.47% and 10.33% respectively. Although a direct comparison cannot be made because the Roos (1992) study examined only the elderly, this study found a 30 day case fatality rate of 5.5% and a one year rate of 7.4%. When the concurrent valve replacement procedure was removed from this analysis, the 30 day rates drop to 4.9% and the one year rates drop to 6.56%.

The region with the highest utilization of CABS did not have the highest case fatality rates. While the Winnipeg Region had the highest utilization rates for CABS, followed by the Rural Region with the Western Region having the lowest utilization rates, the highest case fatality rates at both 30 days and one year were found in the Rural Region. While the Western Region had the lowest utilization rates, it did not have the lowest 30 day case fatality rates; Winnipeg which had the highest utilization rates had the lowest 30 day case fatality rates. Winnipeg and the Western Region had the same low one year case fatality rates. Due to the small number of deaths occurring over the course of the study, regional differences were only significant for one year case fatality rates between the Rural Region and Winnipeg, when the time intervals were collapsed into 1987/88-89/90 and 1990/91-92/93.

Several hypotheses are suggested regarding the differential, regional long-term mortality rates. Roos and colleagues (1992) postulate that differences between short and long-term mortality may be accounted for by differences in baseline comorbidity, general health status, life expectancy and factors outside the health care system. Another hypothesis is regional differences in follow-up care. The most distinctive difference in baseline characteristics of residents of the Other Rural Region who had CABS was that they were significantly younger than patients from the other two regions; it may be that these younger patients have more serious CAD. A chart audit to assess whether differences in CAD severity exist between the regions could be conducted. Also cause-specific mortality post-CABS and PTCA should be ascertained and if no regional differences are found, a survey of patients and their associated physicians could be conducted to determine the nature and accessibility of follow-up activities. Secondary IHD prevention activities such as lipid lowering strategies, smoking cessation programs, weight loss programs, etc. should be assessed.

Generally, studies reporting mortality after CABS are often randomized clinical trials (RCT) examining efficacy. Case fatality rates from such studies cannot be directly compared to population-based studies because of the strict patient selection criteria used in the former. Yusuf and colleagues (1994) examined the results of seven RCTs comparing medical therapy with CABS between 1972 and 1984; 30 day case fatality rates were 3.2%. Observational studies often report only 30 day in-hospital deaths so it is difficult to make direct comparison with the Manitoba rates which report 30 day case fatality from both in and out of hospital. An analysis of the 1989/90 MedisGroups database of 3,240 PTCA patients and 5,882 CABS patients in the U.S. reported 30 day in-hospital case fatality rates of 0.6% for PTCA and 4.8% for CABS respectively (Hartz, Kuhn, Green & Rimm, 1992). Risk-adjustment was performed and the relative mortality for CABS versus PTCA was 1.72 for all patients and 2.15 for low risk patients. The Swedish Council on Technology Assessment in Health Care (Johansson et al. 1994) reviewed published literature from 1982 to 1990 and found no new RCTs comparing

CABS with medical therapies. However, one report of CABS in-hospital mortality at one site noted an increase from 1.2% in 1981/82 to 3.1% in 1987/88. A review of eleven observation studies identified mortality rates in older patients which ranged from 6% to 12%, with a weighted average of 5.9%. The increase in mortality was due to different patient selection; patients were older, had more three-vessel disease and diabetes. The population-based, Ontario mean CABS in-hospital case fatality rates were 3.01% in FY 1991/92 and 2.88% in FY 1992/93. When a risk adjustment index was used to compare five Ontario hospitals' case fatality rates in 1992/93, the rates ranged from 0.9% to 18.8% (Tu, Jaglal, Naylor et al. 1995). These rates are difficult to compare because they are in-hospital mortality rates occurring at any time. In New York State, the in-hospital case fatality rates (risk-adjusted rates are contrasted in brackets) were: (a) 3.5% (4.17%) in FY 1989/90, (b) 3.14% (3.28%) in 1990/91, (c) 2.63% (3.03%) in 1991/92, and (d) 2.78% (2.45%) in 1992/93 (Hannan et al. 1995).

In Manitoba, annual, mean, CABS with concurrent valve replacement (valve replacement removed in brackets) 30 day case fatality rates were: (a) 5.02% (4.68%) in 1987/88, (b) 6.25% (5.75%) in 1988/89, (c) 7.31% (6.28%) in 1989/90, (d) 6.83% (6.27%) in 1990/91, (e) 3.21% (2.17%) in 1991/92, and (f) 4.94% (4.64%) in 1992/93. The weighted Manitoba average for 30 day CABS case fatality is 5.5% (4.91%). While the rate fluctuates, it is generally higher than recent Ontario and New York State. Differences in definitions means that Manitoba rates are likely an overestimation because they include all deaths within 30 days whereas the Ontario rates are in-hospital deaths at any time and the New York rates are in-hospital 30 day deaths. In a previous study

Manitoba 30 day CABS (with/without valve replacement) case fatality rates in the elderly in 1980/81-1986/87 were higher (7.1%) than those in New England (6.4%), but one and three-year rates were superior (Roos et al., 1992). When valve replacement is deleted from this study, 30 day rates were 4.91% and one year rates were 6.56%. The fluctuation in the annual Manitoba rates bears further investigation. With only two hospitals performing CABS in Manitoba, risk-adjustment is recommended in future studies for inter-institutional comparisons.

PTCA Case Fatality

As opposed to CABS case fatality, lower PTCA 30 day and one year case fatality rates are reported in the literature. From 1987/88 to 1992/93, the mean 30 day case fatality rate for PTCA in Manitoba was 2.1% and the one year case fatality rate was 3.8%. While Winnipeg had the highest utilization for PTCA, followed by the Rural Region with the Western Region having the lowest rates, the Western Region had the highest case fatality rates at both 30 days and one year. Further, the Western Region's 30 day rates were 28.6% higher than Winnipeg and 50% higher than the Rural Region. By one year, the magnitude had decreased and the Western Region's PTCA rates were 13.2% higher than Winnipeg and the Rural Region. While there are insufficient numbers of deaths after PTCA to detect significant regional differences even when the years are collapsed into two time intervals, a trend towards an inverse relationship between utilization and mortality exists. While survival analyses did not identify region as an independent variable for decreased survival, the case fatality trends suggest that patients from the Western Region are referred later in the course of their disease. Continued monitoring of regional case fatality is required to confirm or rule out this trend.

An indepth examination of PTCA patients in the MedisGroups database identified that in-hospital mortality for 30 hospitals in 1989/90 in the U.S. ranged from 0% to 2% (Hartz et al. 1992). PTCA mortality rates in nine observational studies ranged from 0.4% to 1.4% and the weighted average was 0.7%. (Johansson et al. 1994). Nine studies also examined PTCA mortality in elderly patients; mortality rates ranged from 1.4% to 15.0% and the weighted average was 2.3%. In Manitoba 30 day annual PTCA case fatality rates were: (a) 3% in 1987/88, (b) 1.3% in 1988/89, (c) 3.25% in 1989/90, (d) 1.8% in 1990/91, (e) 1.3% in 1991/92, and (f) 2.4% in 1992/93. The Manitoba weighted average for 30 day PTCA case fatality rates was 2.1% and while a direct comparison between 30 day in-hospital and 30 day case fatality rates cannot be made, Manitoba rates are in the same range as other jurisdictions.

CHAPTER 7

Conclusion

This study examined the utilization of, and outcomes associated with, angiography, CABS and PTCA. A longitudinal, observational design was used and all residents who had angiography in Manitoba during FY 1987/88-1992/93 were followed to determine if they had CABS and/or PTCA. Individual, longitudinal histories were constructed from three Manitoba Centre for Health Policy and Evaluation (MCHPE) files: (a) Manitoba Health hospital file, (b) MCHPE registry, and (c) Statistics Canada's 1986 census file. Using angiography as the screening procedure for entry into the study, the longitudinal histories consisted of up to four angiogram, two CABS and four PTCAs.

Baseline differences in patients who had CAD Procedures

There were 10,512 patients who met the inclusion criteria and who had an index angiogram over the six years of the study, 2,038 (19.4%) went on to have an index PTCA and 2,661 (25.3%) to have an index CABS. The impact of six sociodemographic and clinical variables prominent in the literature and available in the MCHPE database was the focus of the investigation. The first question posed was: "Do Manitoba patients having the three CAD procedures vary on baseline characteristics and if so, how do these variations compare to those found in other studies?"

Age. Manitoba patients were comparable in age to patients in other studies (Hannan et al., 1992; McGlynn et al. 1994; Hannan et al., 1994). Likewise, a shift towards increased utilization in the elderly and decreased utilization in younger patients occurred in Manitoba for all procedures. Age-related utilization of the procedures reflects: (a) the natural history of CAD, (b) changing demographics, (c) a more aggressive approach towards treating CAD in the elderly, (d) improved procedural techniques resulting in better outcomes, and (e) an indication of decreased incidence of CAD in the young.

Gender. The proportion of Manitoba women to men was similar to other studies (Hannan et al. 1990; Hannan et al. 1992; McGlynn et al. 1994; Tu, Jaglal & Naylor, 1995); one quarter to one third as many Manitoba women as men had coronary artery procedures. The central issue was whether these gender differences reflected a systematic underrepresentation of women with the same disease burden as men. When procedural utilization by ten year age intervals was examined, an age shift in gender utilization in the expected direction occurred, which reflected both an age-delayed manifestation of CAD in women and a survivor effect in which more older women are alive to develop CAD. This mirrors the epidemiology of CAD in which "...women have half the amount of CHD of men and only begin to closely approximate the male rate in old age" (Lerner & Kannel, 1986, p. 384). When examination of gender extends further than an analysis of absolute differences in baseline characteristics, most studies find that gender ratios differ by age groups (Krumholz et al. 1992; Petticrew, McKee & Jones, 1993). Only one study reported no differences in age-specific gender utilization (Tobin et al. 1987).

In keeping with other studies (Khan, Nessim, Gray, Czer, Chaux & Matloff, 1990; Arnold, Mick, Piedmonte & Simpfendorfer, 1994) Manitoba women were significantly older than men at all CAD procedures. Women were, on average, three years older then men at angiography and CABS, but six years older at PTCA. The later may reflect referral hesitancy on the part of physicians due to the higher mortality in women after PTCA reported in earlier studies or may also reflect treatment preferences on the part of women. That this delay exists for PTCA and not for CABS may be due to the fact that PTCA is used in less severe CAD where medical treatment remains a reasonable alternative. This additional three year mean age difference between angiogram and PTCA in women and the reasons and implications for this difference, requires further investigation. It is difficult to position these age differences in Manitoba with other studies because no other population-based study has followed a cohort of angiography patients to determine whether they had CABS or PTCA and thus age differences at time of procedure are not available.

Region of Residence. Regional differences occurred among all sociodemographic variables suggesting that different referral selection criteria are used. More Winnipeg patients were referred for all procedures than from the other two regions. Angiography and CABS patients from the Other Rural Region are referred at a younger mean age than patients from the Western Region and Winnipeg. Regional access to coronary artery procedures differed between the genders; women outside of Winnipeg have relatively higher rates. Regional differences were also found amongst income quintiles. In Winnipeg, as income increased there was an increase in the number of patients referred for angiography, PTCA and CABS. In the other two regions, the trend in utilization was in the opposite direction and no gradient was observed.

Differential access outside of Winnipeg is a worrisome finding because CAD procedures are centralized in Winnipeg. Since there is no evidence that the gender distribution or the incidence of IHD differs among the regions, it is assumed that either different selection criteria are used or that women's treatment preferences vary by region. No rationale is apparent for the lower referral rate for Winnipeg men as opposed to Winnipeg women or the increased referral for younger men in the Other Rural Region which underscores the fact that the "right rate" for coronary artery procedures is not known. While this study design can address whether these regional differences in referral patterns decreased the risk of survival for CABS and PTCA patients, a retrospective chart audit of the appropriateness of CAD utilization across regions is suggested to assess whether the different selection criteria affect appropriateness.

Income. Since Manitoba patients have national health insurance and ability to pay is not a barrier to health care, it was anticipated that the inverse relationship noted between income and CAD would exist for CAD procedures. However, results were mixed. The largest percentage of angiogram and CABS patients were from were from quintiles 2 and 3. Angiogram and CABS patients in the lower quintiles were older. The income-procedural rate relationship was in the expected direction for women (i.e. increased utilization in the poor), but not for men; additionally a strong linear relationship across the quintiles was found for angiography. It may be that the inverse relationship for men indicates that men from the most affluent neighbourhoods are less tolerant of anginal pain, more informed about treatment modalities and prefer more aggressive testing/treatment. While different selection criteria or patient preferences may explain the findings in men, it is also plausible that gender is confounded by age, severity or some other variable. Also, for reasons not clearly understood, the measure of income may lack precision in women.

Differences in comorbidities across income quintiles were noted and again results were mixed. Larger percentages of angiography patients with CHF and diabetes were from the lower income quintiles, while CABS patients with coagulopathies were more likely to come from quintiles 2 and 5. In a country with national health insurance it was reassuring to find no relationship between income and waiting time for CABS and PTCA. These mixed results may indicate that data on the average household income of families in the area of residence of the patient are an imprecise proxy for individual data and that this imprecision is causing some "noise".

Comorbidities. In comparison to comorbidities obtained from primary data collection as summarized in Table 5, administrative data would appear to under record comorbidities. However, three of the four comorbidities reported most frequently using primary data collection (Table 5) were also reported most frequently in this study. They were: (a) previous AMI, (b) CHF, and (c) diabetes. Romano, Roos, Luft, Jollis and Doliszny (1994) also found that diabetes and CHF were recorded with similar frequency in administrative and clinical databases but that previous AMI was under recorded in administrative data. To illustrate the diversity of findings in this relatively new field of comorbidity adjustment, only previous AMI was among the four most prevalent comorbidities in the Romano et al. (1994) study.

A limitation of this study is that comorbidities could not be separated from complications. Some investigators have found that abstracting diagnostic codes from prior hospitalizations can distinguish pre-existing comorbidities from procedural complications (Romano et al. 1994). This study identified that of the ten medical comorbidities assessed, nine were recorded less frequently for angiography than for CABS or PTCA. Thus, these data suggest that when the prior hospitalization is for a procedure that can be performed on an ambulatory basis such as angiography, the yield of additional comorbidities may be small. Recent revisions in the Canadian Institute Health Information coding abstract will allow comorbidities to be separated from complications in future studies. It is possible that individuals had more than one comorbidity, but in this analyses, as in others, comorbidities were examined singly. In summary, CABS patients had more comorbidities recorded than PTCA patients.

Waiting Time. In a resource constrained environment, waiting time is an important policy issue. Longer queues for surgical procedures are said to exist in countries with national health insurance. A recent study using a random sample of 1,089 angiography and CABS patients Ontario and British Columbia and 2,669 from New York State also examined time from angiogram to CABS and found that Canadian patients with left main disease waited significantly longer than New York patients (McGlynn et al. 1994). Most health services researchers would acknowledge that rationing occurs in all countries; the debate centres around whether queue-based rationing is fairer than price- or income-based rationing.

For this study, waiting time was defined as the time interval between index angiogram and index CABS or PTCA. It is acknowledged that this definition includes decision-making time for both physician and patient, as well as queuing time for the procedure. Since no computerized waiting list was used in Manitoba, this definition was the best available using administrative data.

The distribution of waiting time was skewed and it was thought that patients who waited a year or more were clinically different from those who waited less than a year and so the data was trimmed at one year. The mean waiting time between angiogram and PTCA was 30.4 days; 50% had their revascularization within 11 days and 75% within 36 days. The mean waiting time between angiography and CABS was 65.4 days; 50% of CABS patients had their procedure within 25 days of angiography and 75% within 99 days.

While PTCA patients who waited over 365 days were significantly older than those who waited less, the older age may be artefactually related to the longer wait. In contrast, CABS patients who waited 0-30 days were significantly older than those who waited longer. Gender differences in waiting time were found: more women had PTCA within 0-30 days and CABS within 0-90 days. No consistent regional differences or income differences were found. When patients have CHF or previous AMI, the time between angiogram and PTCA or CABS differed; without information on the extent of CAD, this finding is difficult to interpret.

In summary, lack of differences in waiting time among the regions is an important finding. Where a patient lives does not influence when a procedure is performed, rather it is thought that clinical indicators determine the urgency of the procedure. Support for waiting time acting as a proxy for severity of CAD in administrative databases is provided from the findings related to age, gender and comorbidities. To test the hypothesis that waiting time is a proxy for CAD severity, a retrospective chart audit could be conducted to examine the relationship between waiting time and severity of CAD as indicated by the results of angiography. Confirmation of such a finding could be an important contribution to the use of administrative data in health services research.

The central question of: "Do Manitoba patients wait too long?" cannot be answered due to insufficient clinical information. Naylor and colleagues (1992) surveyed cardiac specialists in Ontario to obtain consensus on the maximum tolerable waiting times for different types of CABS and PTCA patients. On a seven point scale, times ranged from immediate revascularization (1), to a marked delay (7) at three to six months. Using this urgency rating scale, Naylor and associates (1993) conducted a retrospective chart audit of 193 angiographically-confirmed patients who had CABS at four Toronto hospitals in 1987 and found that waiting time was related to symptoms. Over half the patients waited longer than the recommended waiting times; mean waiting time was 81.7 days (rated as "6 = delayed") and ranged from 31.3 days (rated as "5 = short list") to 111 days (rated as "7 = marked delay") at the four sites; correlations between actual and maximum recommended waiting times was moderate ($\underline{r}$ = .42 to .47) and differences among centres remained significant after controlling for urgency scores. This data represents the only objective benchmark available for comparison. Unfortunately, the Manitoba data cannot be compared on the Naylor scale because insufficient clinical data (symptoms, anatomy and non-invasive test results) are unavailable in the dataset. Of particular interest is the fact that 25% of Manitoba CABS and PTCA patients would have been rated as either questionable or inappropriate using the scale, which may be an artefact of the upper boundary selected for the scale or discrepancies between actual and recommended times. Replication of the Naylor study on a random sample of Manitoba charts could address actual versus recommended waiting times. Further, for patients who exceeded the recommended waiting times, the psychosocial (Peiper, Lepczyk & Caldwell, 1985) and economic (Dupuis, Kennedy, Perrault, Lambany and David, 1990) impacts should be assessed.

Survival

Having examined the baseline characteristics of patients having CAD procedures in Manitoba, the study went on to assess whether these characteristics affected survival. The question asked was: "What are the relative risks associated with decreased survival after CABS or PTCA in Manitoba, controlling for the specified sociodemographic and clinical variables?" Randomized clinical trials are designed to answer questions concerning efficacy, not effectiveness. Since RCTs are prospective, primary data collection is standard. RCTs often are prone to selection bias, and results may not be generalizable to populations in which the procedures are performed under routine conditions in a broader range of patients. Observational designs using hospital discharge abstracts typically lack longitudinal data and follow-up ability. Thus only in-hospital mortality and not survival analyses can be calculated. This study was designed to assess the effectiveness of CABS and PTCA in the Manitoba population between FY 1987/88 and 1992/93 using a longitudinal, observational design. The presence of a registry and the longitudinal histories enabled survival analyses to be conducted.

Procedure

Unadjusted survival curves indicated a superior survival advantage of PTCA over CABS throughout the six years and in the partial Cox proportional hazard analyses (excluding comorbidities), CABS patients had a 67% higher risk ratio for mortality. However, in the full model (comorbidities included), the increased risk associated with CABS disappeared. Thus once the data is fully adjusted, Manitoba PTCA and CABS patients did not differ in survival. Since Table 3 indicated that CABS patients had a larger percentage of comorbidities, it is reasonable that the risk was shifted from the procedure to the comorbidities. If the MCHPE database had data on other clinical conditions such as: ejection fraction, severity of angina, location of CAD, number of diseased vessels, etc., the results may have differed. In their meta-analysis of 10 year results of RCTs comparing CABS with medical therapy, Yusuf et al. (1994) identified that CABS patients who were more severely compromised achieved greater improvements in their prognosis with significant reductions in mortality. Observational data results are mixed; Hartz and associates (1992) found no differences in one year mortality for high-risk Medicare patients but better survival for low-risk PTCA patients. Using no risk stratification, Webb and colleagues (1990) found similar ten-year survival rates for CABS and PTCA patients.

This study could not examine the efficacy of CABS compared with PTCA; when patients are matched on CAD and randomly assigned to CABS or PTCA, the ERACI study found no difference in perioperative mortality or one-year mortality in patients with multi-vessel disease (Rodriguez et al. 1993). In the RITA RCT, no differences in two-year survival rates were found for patients with single vessel disease (RITA, 1993). Thus, recent RCTs have demonstrated the efficacy of CABS and PTCA and this Manitoba study has addressed the effectiveness of the procedures in a general population.

Age

Many baseline differences in age were noted in the descriptive analyses and a shift to increased utilization in the elderly was found. Most studies have identified that increased age conferred increased risks. In the age-adjusted survival curves, survival was lowest in those 75 and over, for both CABS and PTCA. Age 65 and over conferred twice the risk of increased mortality as age 64 years and under in both the partial (RR = 2.3) and full Cox proportional hazards models (RR = 2.1). It has been suggested that the increased hazard posed by age can be reconciled with the shift to increased utilization in the elderly by the increased quality of life experienced by the recipients; validation is required. While observational studies have demonstrated the feasibility of the procedures in the elderly, RCTs are required to resolve the efficacy of CABS and PTCA in this age group. As with any established technology, it may be difficult to acquire sufficient numbers of participants (physicians and patients) to conduct such a trial.

Gender

Baseline differences between gender and other demographic and clinical variables were found in the descriptive analyses. The gender-adjusted CABS and PTCA survival curves indicated that women had a significantly lower probability of survival than men for both procedures and that this difference remained consistent over time. However, in both the partial and full Cox models, gender did not confer an elevated risk ratio.

This is an important finding as it suggests that in Manitoba, women who are referred for CABS or PTCA do not incur different risks for survival than men, since when other covariates are controlled for, no gender effect is found. This study found that women are older than men at CABS and PTCA and it is likely that the risk for women is associated more with age than with gender.

Administrative data do not contain the results of CAD diagnostic tests and cannot address whether women are appropriately referred for coronary artery procedures; rather a prospective cohort study using primary data containing the results of angiogram and/or non-invasive ischemic testing is required to determine the adjusted odds ratio for utilization of coronary artery procedures in men and women.

Region

Although baseline regional differences were found, region did not confer an elevated risk in either the partial or full Cox proportional hazard models. While different referral criteria and reluctance to refer from outside of Winnipeg had been speculated as the reasons for geographical variations in utilization, this differential access did not confer elevated risks for those who were referred. However, neither underutilization of less severely ill, appropriate CAD patients nor overutilization in Winnipeg can be ruled out. An appropriateness study on a regionally stratified, random sample of charts is recommended.

Income

While unusual baseline differences between income and other variables were found, income as an independent variable conferred no elevated risks in either the partial or full Cox models. In the partial model, an interaction between the highest income quintile and the oldest age was found which conferred twice (RR = 2.4) the risk of decreased survival, but the interaction disappeared in the full model. This suggests that older patients from the most affluent neighbourhoods are more likely to have two comorbidities, coagulopathies and CHF; since this is not supported by the baseline analyses, the interaction may be spurious. Anderson and colleagues (1993) have suggested that wealth and not income (as measured by Statistics Canada's census income) may be a better indicator of SES.

Comorbidities

While comorbidities were not frequently recorded, some baseline differences in the characteristics of patients who had comorbidities were found. The impact of comorbidities on survival analyses could be clearly seen when a partial model without comorbidities was compared to a full model which included them. In the partial model, an interaction between age 75 and over and quintile 5 (RR = 2.4) conferred the highest relative risk, followed by age over 65 (RR = 2.38) and CABS (RR = 1.7). However, when comorbidities were entered into the model, the apparent survival benefit of PTCA and the interaction disappeared, while the risk ratio for age over 65 declined only slightly (RR = 2.1). On the other hand, the highest risk ratio was conferred by comorbidities: congestive heart failure (RR = 2.9) and coagulopathies (RR = 2.5).

In a major review of CABS studies (Leape et al. 1991), only one preoperative predictor of operative mortality was found: CHF (RR ranged from 5.1 in the early 1970's to 10.4 in the early 1980's) Diabetes and renal insufficiency have also been noted as CABS risk factors in large observational studies (Johansson et al., 1994). In the Luft and Romano (1992) CABS study, the logistic coefficients for coagulopathies were 1.1 and for CHF were 1.2. Tu and colleagues (1995), in their recent summary of six major cardiac risk studies, identified fifteen pre-existing comorbidities found to be predictive of mortality and morbidity. Yet in their development of a risk index, Tu and associates (1995) found only one clinical indicator to be predictive of mortality, intensive care stay and hospital length of stay: left ventricular function based on ejection fraction as assessed by echocardiography or angiography. The New York State PTCA registry identified no comorbidities as risk factors for in-hospital mortality (Hannan et al. 1992). The fact that in this Manitoba study, the comorbidities found to be predictive of increased CABS and PTCA mortality were coagulopathy and congestive heart failure, provides support for the validity of the Luft and Romano comorbidity scheme. These comorbidities are also found in other major studies, including studies where comorbidities are more reliably reported that is, those using primary data collection.

It is however possible, that the comorbidities found in this investigation are a complication of CABS or PTCA and not a pre-existing comorbidity. Complications cannot be distinguished comorbidities in this study. One method to distinguish these in administrative, longitudinal databases is to determine if the comorbidity was recorded on the hospitalization prior to the procedure. Table 3 identifies that this would hold for CHF but that fewer coagulopathies were reported on the angiography record than on the CABS record. Also there is less reason to think that comorbidities are recorded accurately on the angiography record because there is a lack of incentives to record these on ambulatory procedures. Since 1987, the Canadian Institute of Health Information has required coding of a variable DXTYPE for diagnostic codes; while complications can be distinguished from comorbidities using this variable, it was not until 1990/91 that DXTYPE variables were associated with more than 99% of cases in Manitoba (Roos et al. 1995). Now future studies can now benefit from using this variable. Waiting time

Waiting time varied across baseline characteristics for patients having CABS or PTCA. While this database lacked the clinical variables required to assess the appropriate waiting time, the impact of waiting on survival of CABS or PTCA patients could be assessed. When survival curves were adjusted for waiting 0-30 days between angiogram and CABS or PTCA, CABS patients who waited 0 days had the lowest probability of survival, followed by PTCA patients who waited 0 days. As waiting time interval increased, survival increased, although in each time interval CABS patients had a lower probability of survival. When waiting time was entered into the partial or full Cox proportional hazard model, having either CABS or PTCA on any day but the same day as angiogram resulted in a decreased risk. In the partial model, the risk ratio was 0.6 for days 1-30 and 0.38 for days 31-365. When comorbidities were entered into the model, the risk ratio decreased slightly to 0.6 for days 1-365. These findings support the fact that physicians prioritize patients who need same day procedures accurately and that the severity-based queuing system associated with national health insurance is performing well. These findings provide support for viewing time between angiogram and CABS or PTCA as an indicator of severity of illness, specifically severity of CAD. Indeed, an important finding from this study is the potential for waiting time to serve as a proxy for severity of CAD in administrative databases.

Utilization Rates

Growth

Trends in utilization rates were an important focus of this inquiry. Slight (4.9%) growth occurred in the Manitoba population from 1982 to 1992, however the 75 and older age group increased by 30.6% (Manitoba Health 1982-83, 1992-93). The greatest increase in CAD procedures utilization occurred in the elderly. While cardiovascular mortality is declining in Canada, it remains the leading cause of death and hospitalizations. Examining coronary artery procedure utilization, unadjusted mean provincial rates per 10,000 were 28.9 for angiogram, 6.5 for CABS and 6.0 for PTCA. Between 1987/88 and 1992/93 angiogram rates grew by 50%; there was a 181% increase between 1979/80-1984/85 rates reported in an earlier study (Roos & Sharp, 1989) and the current rates. CABS rates grew by 20% and this represented a 38.3% increase since the earlier study. While no previous Manitoba data was available for PTCA, rates grew by 27%. Growth in Manitoba rates is similar to other Canadian jurisdictions, but slower than in the U.S.

The growth in angiography rates indicates a aggressive approach to the diagnosis and treatment of coronary artery disease, especially in the elderly. This responsiveness is possible because the procedure is usually performed on an ambulatory basis and scheduling can more easily be expanded since capital costs are not involved. In comparison, the more modest growth in CABS and PTCA reflects a capping of the procedures by the provincial government and shifting of utilization of PTCA to patients with less severe CAD.

Age-Specific Rates

However, a dominant reason for growth in coronary artery procedures is increased use in the elderly which is occurring across North America. Age-specific utilization of angiography increased in all age groups with the largest increase occurring in those 65 and older. In contrast to the previous study, CABS rates decreased in the 25-64 age group, but both studies found increased utilization in the elderly. PTCA rates decreased over the study period in the 25-34 age group and increased in all other age groups, with the largest increase in the 75 and over group. Decreased utilization in the younger age groups reflects stabilization of CABS as an accepted technology, shifting of revascularization in this age group to PTCA and perhaps decreased incidence related to prevention. Increased utilization in the elderly is reflective of changing demographics, a survivor effect in which more elderly are alive to present with CAD, improvements in technology leading to better outcomes and a more aggressive approach to CAD due to improved technology. While observational studies have demonstrated the feasibility of CABS and PTCA in the elderly, all studies including this one have identified that the elderly face double the risk of mortality based solely on age. Clearly, additional types of studies are now required. They are: (1) a multi-centre randomized clinical trial assessing the efficacy of CABS and PTCA in the elderly, and (2) assessment of the quality of life in elderly patients with comparable CAD who have medical treatment as opposed to CABS and PTCA.

Gender-Specific Rates

Manitoba gender-specific rates approached those in other jurisdictions with men having two to three times as many coronary artery procedures as women. For angiography and CABS, rates grew slightly in both genders over the study period, while for PTCA the rates grew faster in women. With angiography serving as the funnel to CABS and PTCA, it was anticipated that the CABS and PTCA gender-specific rates would parallel those of angiography. While this occurred for PTCA, the ratio did not hold for CABS suggesting that a male gender referral bias may be operating. However, gender-specific results of angiography are required to assess whether gender-specific CABS and PTCA rates are appropriate.

Income-Specific Rates

The literature reports an inverse relationship between income and CAD. Statistics Canada census data on average household income of families in the area of residence of patients was used as the measure of socioeconomic status. An unexpected pattern emerged in which those from the least affluent neighbourhoods had the lowest utilization rates for angiography in every year, for CABS in four of the six years and in PTCA in three of the six years. Only one other study has examined the impact of income on CAD procedures, that is on CABS (Anderson et al. 1993). It found that the nonelderly in Manitoba, Ontario and British Columbia living in the least affluent neighbourhood had slightly higher rates than those from the most affluent neighbourhood, while the elderly living in the most affluent neighbourhoods had the highest rates. Since income should not be a barrier to utilization in a province with a national health insurance system, it may be that the average income of families in the area of residence of the patient is an imprecise proxy for individual data and this imprecision is causing some "noise".

Regional Rates

Of particular interest were regional utilization rates since a previous study had noted lower angiography and CABS rates in the Western Region with no regional variation in IHD indicators (Roos & Sharp, 1989). Those findings were widely disseminated and discussed and it was anticipated that the trend would be reversed. Regional utilization patterns are vital to track because CAD procedures are centralized in Winnipeg and access is an important issue.

In this study, the Western Region continued to have the lowest crude rates relative to the provincial rates for every procedure. The Other Rural Region had the second lowest rates and Winnipeg had the highest rates. Rates for the Other Rural Region approximated those for the province as a whole, while Winnipeg rates exceeded the province. Regional unadjusted rates were not affected by age, sex or income adjustment indicating that differences in regional crude rates are not caused by differences in the underlying distribution of age, sex and income in the province as a whole.

Geographical variations in utilization are commonly related to variations in physician practice patterns. The findings from this study support continued underutilization and regional referral bias in the Western Region noted in the earlier study (Roos & Sharp, 1989) and investigation into practice patterns is warranted. Angiography precedes CABS and PTCA and regional angiography referral bias is especially worrisome since angiogram acts as a funnel, that is, referral for angiography determines subsequent regional differences in CABS and PTCA. However, Carlisle, Valdez, Shapiro and Brook (1995) postulate that variation in utilization may also be influenced by the geographical availability of diagnostic tests and treatments. This finding would not appear to be supported in that the referral rate in the Other Rural Region approximated that of the province as a whole. Distances from the Other Rural Region to Winnipeg are similar, or even greater than, from the Western Region. One hypothesis put forward in the previous study was fear of loss of income on the part of physicians in the Western Region. Since no evidence supports this hypothesis, a qualitative design is suggested to address the following types of questions. Regarding communication and collegiality one could ask: "When patients are referred for angiography, CABS or PTCA, are the results and therapeutic plans conveyed to their primary care physicians in the regions in a timely fashion?" Regarding perceptions of potential loss of income, one could ask: "When patients outside Winnipeg are referred for angiography and have CABS or PTCA, who manages their IHD care after the procedure?" To definitively answer the question, comparisons of visits to family physicians and Winnipeg cardiologists after CABS or PTCA can be made between Western Region and the Other Rural Region by linking the physician claims file and this longitudinal file to track post-CABS and post-PTCA physician utilization.

Variations in physician practice patterns are also influenced by uncertainty regarding outcomes. Lacking evidence, local physician cultures prevail and physicians weigh their experience and opinions to inform practice decisions. By 1991 the mid-point of this study, both of the major Rand reviews on the efficacy and appropriateness of

CABS and PTCA had been published (Hilborne et al. 1991; Leape et al. 1991). The supposition that only physicians in the Western Region were unaware of the technological improvements in the procedures that resulted in declining mortality associated with CABS and PTCA in recent years is not tenable.

Region of residence was not an independent predictor of decreased survival. However, this study cannot fully address whether the regional differences in utilization rates represent deficiencies in clinical practice. If the Western Region's patients were referred later in their disease, one would expect an increased risk ratio. Similarly, if overutilization within Winnipeg was occurring and less severely ill patients were referred, a decreased risk ratio would have been anticipated. In rejecting the region of residence hypothesis, one risks a type I error, rejecting a true null hypothesis. A longitudinal, observational study in which the cohort is assembled at an earlier point in the etiology of CAD is recommended. Patients who present with symptoms of CAD should be followed to determine their diagnostic pathways, the results of diagnostic tests and regional referral rates for the procedures. Such a design also allows assessment of the impact of regional variances through follow-up of those who were not referred.

Case Fatality Rates

CABS Case Fatality Rates

This analysis of population-based mortality rates presents the case fatality rates for CABS and PTCA performed on a general population. As in other jurisdictions, Manitoba's 30 day and one year case fatality rates are higher for CABS than for PTCA. The mean provincial CABS 30-day case fatality rate was 5.5% and the mean one-year case fatality was 7.4%. The weighted average in-hospital case fatality rate in Ontario between FY 1991/92-1992/93 was 2.95% and the 30 day in-hospital case fatality rate in New York State was 3.0% between FY 1989/90-1992/93. Differences in definitions means that Manitoba rates are likely an overestimation because they include all deaths within 30 days, whereas the Ontario rates are in-hospital deaths at any time and the New York rates are in-hospital 30 day deaths. In a previous study Manitoba 30 day CABS (with/without valve replacement) case fatality rates in the elderly in 1980/81-1986/87 were higher (7.1%) than those in New England (6.4%), but one and three-year rates were superior (Roos et al., 1992). When valve replacement is deleted from this study, the 30 day rates drop to 4.9% and the one year rates to 6.56%.

For a more accurate picture in the future, it is recommended that a risk-adjustment index be applied to Manitoba's data to control for differences in patients' mortality. Also since only two hospitals in Manitoba perform the procedures, consideration should be given to comparing risk-adjusted, hospital-specific, case fatality rates. Because the rates fluctuated annually, investigation into the volume-outcome relationship of individual physicians may be warranted by the College of Physicians and Surgeons. The first step suggested is to determine what the surgeon-volume is for individual practitioners in Manitoba and to compare this caseload with that in other jurisdictions. It should also be pointed out that both Ontario and New York State have computerized cardiac care networks. Since physicians in these jurisdictions are aware that their practices are being closely monitored, a change in patients selection may have occurred with less severely ill patients being referred for the procedures. This underscores the importance of applying risk-adjustment strategies to Manitoba, prior to the introduction of computerized registries/ waiting lists, etc.

There were few deaths within one year (n = 208) over the course of the study and no significant differences in 30-day or one-year case fatality rates were detected among the regions in any year, although the Other Rural Region consistently had the highest 30-day and one-year rates. When the years were collapsed into time intervals of 1987/88-1989/90 and 1990/92-1992/93, a significant difference in one-year rates was found between the Other Rural Region (with the highest rates) and Winnipeg (with the lowest rates). Several hypotheses are suggested for the differential, regional long-term mortality rates: differences in baseline comorbidity, general health status, life expectancy, factors outside the health care system and differences in follow-up care. However, region of residence was not found to be an independent predictor of decreased survival in the Cox proportional hazards model and likely the small number of deaths leads to these spurious results.

PTCA Case Fatality Rates

The Manitoba weighted average 30-day case fatality rate compares favourably with that in other jurisdictions. The mean provincial PTCA 30-day case fatality rate was 2.1% and the mean one-year rate was 3.8%. While not comparable rates, the literature reports in-hospital PTCA mortality rates that range from 0% to 2% (Hartz et al. 1992). There were few deaths within one year (n = 99) and wide regional fluctuations. No significant differences between 30-day and one-year case fatality rates were found, but when the years were collapsed to 1987/88-1989/90 and 1990/91-1992/93, there was a trend for the Western Region to have the highest rates at both 30 days and one year. Thus while patients from the Western Region have the lowest PTCA utilization rates, the trends in case fatality rates suggests that patients from the Western Region are referred later in the course of their disease and also receive less follow-up care. Since the survival analyses did not identify region of residence as an independent risk factor, the small number of deaths within one year and the yearly fluctuations may lead to this artificial result or insufficient explanatory clinical information may be available in the database.

Summary

Manitoba patients referred for angiography, CABS and PTCA from 1987/88 to 1992/93 varied on baseline sociodemographic characteristics. They were comparable in age and gender to patients in other studies/jurisdictions and a shift to increased utilization in the elderly was noted for all procedures. Women were also found to be significantly older than men at all procedures. A unique and inexplicable finding was that women who had PTCA were three years older than women who had CABS; this referral hesitancy had not been previously noted in the literature. Regional selection criteria differed and decreased regional access outside Winnipeg was a worrisome finding. Further investigation into the validity of waiting time as a proxy for severity of CAD is warranted: if found, using waiting time as a proxy for CAD could overcome a important deficiency in administrative databases.

Survival analyses identified that, as in other studies, age above 65 conferred an increase risk of mortality; RCTs to evaluate the efficacy of CABS and PTCA in the elderly are recommended. When other covariates are controlled for, procedural and gender effects disappeared. Comorbidities, congestive heart failure and coagulopathies conferred more than twice the increased risk of mortality.

While angiography rates grew fastest, increased growth occurred in all procedures and was accounted for by increased use in the elderly. Variation in rates in the Western Region in the absence of differences in IHD incidence, persisted from an earlier study. Regional rates were not affected by adjustment for age, gender or income. Case fatality rates for CABS were high and while absolute numbers were small, annual fluctuations warrant further monitoring of between-hospital analyses and individual physician-outcome relationships by the College of Physicians and Surgeons. Conversely, case fatality rates for PTCA were low.

Limitations of secondary databases include the absence of clinical data which may enable more accurate predictions of risk factors for decreased survival. The establishment of a computerized waiting list and/or registry which included variables on the results of CAD diagnostic tests would enable Manitoba to better monitor outcomes associated with these cardiac procedures on a prospective basis. Retrospective studies using chart audits are recommended to: (a) assess the appropriateness of CAD procedures in the regions, and (b) compare actual to maximum tolerable waiting times. Further, the utility of alternative indicators of SES from Statistics Canada's census information should be assessed.

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