THE RELATIONSHIP BETWEEN LONG-TERM ADHERENCE TO RECOMMENDED CLINICAL PROCEDURES AND HEALTH CARE UTILIZATION FOR ADULTS WITH DIAGNOSED TYPE 2 DIABETES

by

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ABSTRACT

Background: Diabetes is a common and serious chronic condition. If not well-managed, significant multi-system complications often arise, resulting in increased health care utilization and poor health outcomes. There is considerable evidence that people with diagnosed diabetes are not receiving recommended care. A comprehensive program aimed at improving adherence to recommended care can improve patient outcomes and result in cost-savings. The key aim of this study was to determine whether the long-term receipt of appropriate clinical procedures by patients with type 2 diabetes was associated with higher medical care costs.

Methodology: A cohort of 20,288 diagnosed type 2 diabetes patients was identified using physician and hospital records. An analytic file was created by linking information on patient characteristics with utilization of physician and acute care services during a five-year period (1996 to 2001). Adherence to recommended clinical procedures for the assessment of blood glucose, blood pressure and cholesterol levels, as well as retinopathy and nephropathy, were measured during this same five-year period. Subjects were assigned to both a categorical (low, medium and high) and a binary (low and high) adherence group. Physician and acute care resource use was converted to constant 2000 Canadian dollars. Multivariate logistic regression was used to assess the relationship between patient characteristics, including adherence as a categorical variable, and utilization of physician and acute care services.

Results: Long-term adherence was suboptimal, with patients receiving just 53% of recommended procedures. Adherence to recommended procedures, however, improved during the five year period. Patient characteristics associated with poor adherence include being male, younger, low socio-economic status, having no diabetes-specific complicating conditions and living in certain geographic areas. Patients with high long-term adherence (receiving 73% of

recommended clinical procedures) were 59% *more* likely to use a high level of physician resources but 22% *less* likely to use a high level of acute care resources. On the other hand, patients with low adherence (receiving 31% of procedures) were 28% *less* likely to use a high level of physician resources but 17% *more* likely to use a high level of acute care resources. The utilization difference related to adherence was particularly noticeable in older adults with higher levels of morbidity. Elderly patients in this low adherence group were more likely to be hospitalized (64.3% vs. 55.8% over the five-year period) and, when they were hospitalized, tended to stay in hospital for longer periods of time (11.9 vs. 6.7 days) than patients in the high adherence group.

Conclusion: Improving long-term adherence may result in the avoidance of $4 in acute care costs for every additional $1 in physician costs. If all patients moved into the high adherence category, as much as $3.1 million in annual costs might be avoided across the study sample. If this analysis is applied to all adults with diagnosed diabetes in the province of British Columbia, the annual costs avoided could reach the level of $34.4 million. Systemic changes are required in the provision of primary care to promote long-term adherence to recommended diabetes care.

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ACG	Adjusted Clinical Groups
ACE Inhibitor	Angiotensin-Converting Enzyme (ACE) Inhibitors
ARB	Angiotensin Receptor Blockers
ADA	American Diabetes Association
ADG	Aggregated Diagnostic Group
AIDS	Acquired Immune Deficiency Syndrome
AHCPR	Agency for Health Care Policy and Research
AMI	acute myocardial infarction
APP	Alternate Payment Program
BCCDM	British Columbia Chronic Disease Management
BCLHD	British Columbia Linked Health Database
BCMA	British Columbia Medical Association
CDA	Canadian Diabetes Association
CHSPR	Centre for Health Services and Policy Research
CIHI	Canadian Institute for Health Information
CPG	clinical practice guidelines
CPI	Consumer Price Index
CVD	cardiovascular disease
DAD	discharge abstract database
DAN	diabetic autonomic neuropathy
DCCT	Diabetes Control and Complications Trial
DCA	Diabetic Care of America
DDMP	diabetes disease management program
DPN	distal symmetric polyneuropathy
DR	diabetic retinopathy
EA	enumeration area
EDC	expanded diagnostic cluster
ESRD	end-stage renal disease
FFS	fee-for-service

FHA	Fraser Health Authority
GP	General Practitioner
GPAC	Guidelines and Protocols Advisory Committee
HDL	high-density lipoprotein
HbA1c	glycosylated haemoglobin
HPMG	Health Partners Medical Group
ICD	International Classification of Diseases
IDF	International Diabetes Federation
IDDM	insulin dependent diabetes mellitus
IPPE	income per person-equivalent
LHA	local health area
MRRS	most recently registered specialty
MSC	Medical Services Commission
MSP	Medical Services Plan
NIDDM	non-insulin dependent diabetes mellitus
OOP	out of province
PHCO	Physician Hospital Community Organization
PVD	peripheral vascular disease
QALY	quality adjusted life years
RIW	resource intensity weigh
SES	socio-economic status
SPSS	Statistical Package for the Social Sciences
TOP	type of practice
TRIAD	Translating Research Into Action for Diabetes
UBC	University of British Columbia
UK	United Kingdom
UKPDS	United Kingdom Prospective Diabetes Study
US	United States
VA	Veterans Affairs
VH	Vancouver Hospital
WHO	World Health Organization

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CHAPTER I: INTRODUCTION

During the last two decades, a series of studies have pointed out the unequivocal relationship between the tight control of blood glucose and blood pressure levels in patients with diabetes and a reduction in both acute and chronic complications. This research has been so compelling that the American Diabetes Association offered the following conclusion: "it is time for all health professionals to treat diabetes aggressively. It is also time for patients to take their diabetes with the utmost seriousness. And it is incumbent upon the health care system to provide the necessary resources for both to be successful. Compromise or acceptance of a disadvantageous and dangerous status quo in people with diabetes should not be tolerated any longer" (Genuth et al., 2003, p. S32). In addition to reducing a patient's longevity and quality of life, the complications associated with poorly managed diabetes result in significant costs to the health care system.

The first step in controlling blood glucose and blood pressure is to determine what the appropriate levels should be and then to execute the necessary diagnostic tests to decide if those levels are being achieved. Information on diagnostic test outcomes is rarely available in administrative data sets. On the other hand, it is often possible to determine whether or not a given test was received by a patient and how often that test was received. In this study we used information on the receipt of five recommended clinical tests (as available in the B.C. Linked Health Data set) to determine if there is a relationship between high adherence to the procedures and the use of health care services.

Adherence was measured for the assessment of blood glucose, blood pressure and cholesterol levels, as well as retinopathy and nephropathy, over a five year period. While other studies have assessed adherence to recommended clinical procedures, to our knowledge this is

the first study to consider long-term adherence, including repeated patient exposure to the procedure.

The primary objectives of this study were: 1) to assess whether adherence to recommended clinical procedures changed over time; 2) to determine which patient-level characteristics were associated with low or high adherence; and 3) to determine whether adults with diagnosed type 2 diabetes with higher adherence to recommended clinical procedures utilize more health care services.

CHAPTER II: BACKGROUND

2.1 Diabetes

Diabetes mellitus is a chronic disorder of metabolism. It occurs when the body can no longer absorb glucose due to the lack of insulin production or the inability to use the insulin that is produced. Insulin, a hormone produced in the pancreas, is required for glucose to be absorbed from the blood stream into cells, where the glucose is metabolized to produce energy. Without insulin, or without the ability for the body to use insulin appropriately, glucose remains in the blood stream, starving cells of energy; as well, the excess glucose in the blood stream, over time, may result in damage to a variety of body organs and systems. For instance, if there is not enough insulin for the body's cells to use the available glucose, the body begins to use fat instead, resulting in ketoacidosis; this condition, if left untreated, eventually leads to unconsciousness and death.

There are four main types of diabetes. Type 1 diabetes is an autoimmune disease that occurs when the insulin-producing beta cells in the pancreas are damaged or destroyed, causing a reduction in, or the cessation of, insulin production (Atkinson and Maclaren, 1994). The aetiology of type 1 diabetes is not well understood, but the disease is believed to be the result of an individual's genetic vulnerability together with a possible viral or other infectious trigger; the infection induces an autoimmune response that damages the already vulnerable insulin-producing beta cells in the pancreas (Gavin et al., 2003). The incidence of type 1 diabetes in Canada is highest in children 10-14 years of age (Toth et al., 1997; Blanchard et al., 1997). In Ontario, for example, the incidence rate for female children in the calendar year 2000 ranged from 19.9 per 100,000 among 0-4 year old females to 33.5 among 10-14 year old females (To et al., 2003). Similar results are seen in male children, with the incidence rates ranging from 25.0

per 100,000 among 0-4 year old males to 35.9 among 10-14 year old males. Type 1 diabetes is considerably less common than type 2 diabetes, accounting for less than 10% of persons with diabetes.

Type 2 diabetes is the most common form of diabetes, occurring in approximately 90% of patients with diabetes. Type 2 diabetes results when the pancreas produces sufficient insulin, but the body cannot use the insulin effectively. This condition, known as insulin resistance, causes the pancreas to secrete additional insulin to maintain normal blood sugar levels. In approximately one-third of people with insulin resistance, either the body's cells do not respond to the higher levels of insulin or, over time, insulin production decreases, resulting in the high blood glucose levels of type 2 diabetes (DeFronzo et al., 1992). Obesity and physical inactivity aggravate insulin resistance, contributing to the severity of disease.

While the incidence of type 1 diabetes is highest in children, type 2 diabetes tends to begin manifesting in adults at mid-life (Engelgau, 2004). It should be noted, however, that the prevalence of type 2 diabetes in children is increasing along side the emerging epidemic of childhood obesity (Ludwig and Ebbeling, 2001). There is a steady increase in incidence rates in the older population. In Ontario in 1999, for example, the incidence of diabetes increased from 0.41 per 100 for women 35-49 years of age to 0.95 per 100 for women 50-64 years of age and 1.28 per 100 for women 65-74 years of age (Hux and Tang, 2003). The rates for men were slightly higher, at 0.51, 1.28 and 1.65, respectively.

Twin and family studies have also identified a strong genetic component to type 2 diabetes, with an increased risk among siblings of an individual with diabetes that is at least three times higher than the population at large among individuals with European ancestry (Elbein, 2002; Elbein et al., 2002). The strongest genetic link known at this time is due to variants of the

calpain-10 gene, though a number of other genes have been implicated (Elbein et al., 2002; Carlsson et al., 2005).

Gestational diabetes is the third main type of diabetes. It occurs in approximately 4% of pregnant women who have not had diabetes before (Engelgau et al., 1988). In Canada, the prevalence of gestational diabetes varies from 3.5% to 3.8% in the non-aboriginal population to 8.0% to 18.0% in aboriginal populations (Harris et al., 1997; Godwin et al., 1999; Rodrigues et al., 1999; Dyck et al., 2002). While the aetiology is not well understood, it is believed that hormones from the placenta block the action of the mother's insulin in her body, resulting in insulin resistance and the subsequent build-up of blood glucose levels. Gestational diabetes usually disappears with the termination of the pregnancy but there remains an increased risk for the mother of later impaired glucose tolerance and type 2 diabetes (Henry and Beischer, 1991; Ben-Haroush et al., 2003; Albareda et al., 2003). Women with gestational diabetes have a 17-63% risk of type 2 diabetes within 5-16 years after their pregnancy (Hanna and Peters, 2002).

Finally, the fourth category is diabetes secondary to other conditions. These consist of diabetes associated with genetic defects of beta cell function, genetic defects in insulin action, diseases of the pancreas, endocrinopathies, infections, uncommon forms of immune-mediated diabetes, drug or chemical induced diabetes and other genetic syndromes sometimes associated with diabetes (Canadian Diabetes Association, 2003).

This discussion in this study is limited to type 1 and 2 diabetes.

Diabetes is usually diagnosed when one or more of a set of common signs and symptoms are exhibited by the person or by screening of high-risk individuals, confirmed by a high level of blood glucose. A positive diagnosis of diabetes is made when an individual's test results are

higher than a preset standard on any of three common tests of plasma glucose. These tests, and the related plasma glucose values, include:

- A fasting plasma glucose value of ≥7.0 mmol/L
- A casual (any time of day, without regard to the interval since the last meal) plasma glucose value of ≥11.1 mmol/L.
- An oral glucose tolerance test plasma glucose value of ≥11.1 mmol/L in a blood sample taken two hours after a person has consumed 75 grams of glucose dissolved in water.

A positive result needs to be confirmed by a second positive test on a different day, unless there is unequivocal evidence of hyperglycaemia accompanied by acute metabolic decompensation (Canadian Diabetes Association, 2003).

2.1.1 Diagnosed vs. Undiagnosed Cases

While the diagnosis of diabetes is relatively straightforward, there appear to be a significant proportion of the population with undiagnosed type 2 diabetes (Leiter et al., 2001; Worral and Moulton, 1992). A study in Manitoba (Young and Mustard, 2001) found the prevalence of undiagnosed type 2 diabetes to be approximately 2.2% of the adult population in that province, representing approximately one-third of all type 2 diabetes cases. This proportion is similar to the estimated 2.7% of the population aged 20 years and older in the United States with undiagnosed type 2 diabetes (Harris et al., 1998, Wilder et al., 2005). A recent audit in the United Kingdom estimated that 23% of individuals who have type 2 diabetes have not been recorded as having diabetes by their general practitioners (National Diabetes Audit, 2005).

The fact that between a quarter and a third of people with type 2 diabetes remain undiagnosed is a public health concern. The onset of type 2 diabetes typically occurs at least 4-7

years before clinical diagnosis (Harris et al., 1992). Diabetes-related complications may develop during this time while earlier detection and treatment may reduce the development of these complications (Harris and Eastman, 1996). As presented in the following section, the burden of diabetes-related morbidity is high if the disease is not well-managed. Individuals with diabetes who are undiagnosed are, of course, also untreated. The concern is that preventable diabetes-related complications can develop prior to diagnosis.

2.2 The Provision of Medical Care to Diabetic Populations

2.2.1 The Burden of Diabetes-Related Morbidity

Diabetes is one of the most serious of the chronic diseases, with significant multi-system complications if the disease is not well-managed. Acute complications include diabetic ketoacidosis, hyperosmolar nonketotic coma, and hypoglycaemia, plus a higher susceptibility to common infections (Booth and Fang, 2003). Chronic complications fall into two main categories: *microvascular* (nephropathy, retinopathy and neuropathy) and *macrovascular* (ischemic heart disease, stroke and peripheral vascular disease).

On the acute side, both ketoacidosis and hyperosmolar coma are characterized by severe elevations in blood glucose levels (hyperglycaemia); emergencies associated with these conditions involve life-threatening metabolic disturbances. Patients with type 1 diabetes are more likely to present with diabetic ketoacidosis than patients with type 2 diabetes.

The annual rate of diabetic ketoacidosis is estimated at 46 per 10,000 individuals with diabetes (Faich, et al., 1983; Snorgaard et al., 1989), while hyperosmolar coma occurs less frequently. In a survey of 312 admissions for ketoacidosis and hyperosmolar coma, MacIsaac and co-authors (2002) found that 55% were admitted for ketoacidosis, 15% for a hyperosmolar, hyperglycaemic state, and 30% for a combination of the two. Further, the mortality rate was

1.2% for patients with ketoacidosis, 17% for patients presenting with a hyperosmolar, hyperglycaemic state, and 5.3% for patients with a combined state. Similar results were found in a larger study, with a mortality rate of 4.9% for diabetic ketoacidosis and 14.6% for hyperosmolar coma (Hamblin et al., 1989).

Among chronic complications, diabetic nephropathy affects 25-45% of patients with diabetes (Jawa et al., 2004). In its earliest stages, diabetic nephropathy presents with low levels of albumin in the urine (microalbuminuria). If the course of diabetic nephropathy progresses, it may eventually lead to chronic or end-stage renal failure (ESRD). In fact, diabetes is the leading cause of ESRD, a condition in which the patient requires a renal transplant or dialysis in order to live. The risk of developing ESRD is up to 13 times higher in persons with diabetes than those without the condition (Brancati et al., 1997; Perneger et al., 1994). Over 40% of patients starting dialysis treatment for renal problems in Canada and the United States have diabetes (Canadian Institute of Health Information, 2001; National Institutes of Health, 2001).

Early (non-proliferative) diabetic retinopathy (DR) has a prevalence of at least 70% in persons with type 1 diabetes (Klein et al., 1984a) and 40% in persons with type 2 diabetes (Klein et al., 1984b). Non-proliferative DR may progress to proliferative DR, characterized by the appearance of new retinal blood vessels. If detected early, proliferative DR can be treated with retinal laser photocoagulation to reduce the risk of vision loss (Buhrmann et al., 2003). If left untreated, proliferative DR represents a serious threat to vision, leading to blindness in 50% of patients within 5 years (Caird et al., 1968). Proliferative DR presents in approximately 50% of individuals with type 1 diabetes and 10% of individuals with type 2 diabetes after they have the disease for 20 years (Klein et al., 1984a,b). In individuals under the age of 65, over half of all cases of blindness are caused by diabetes (Jawa et al., 2004).

Diabetic neuropathy is among the most common of the long-term complications associated with diabetes, afflicting an estimated 50% of individuals with diabetes (Young et al., 1993; Dyck et al., 1993). There are a variety of types of diabetic neuropathy, with the most common ones being chronic sensorimotor distal symmetric polyneuropathy (DPN) and diabetic autonomic neuropathy (DAN) (Boulton et al., 2005). DAN primarily affects the gastrointestinal, genitourinary and cardiovascular systems. Gastrointestinal disturbances include esophageal enteropathy, gastroparesis, constipation, diarrhoea and fecal incontinence. Genitourinary tract disturbances include bladder and/or sexual dysfunction. In men, it is associated with loss of penile erection and /or retrograde ejaculation. DAN is also associated with reduced cardiovascular autonomic function, resulting in a doubling of the risk of silent myocardial ischemia. Finally, DAN is associated with dry skin, loss of sweating, and the emergence of fissures and cracks that allow micro-organisms to enter, ultimately contributing to the development of ulcers, gangrene and limb loss (Vinik et al., 2003).

Pain, especially in the lower limbs, is the most outstanding complaint of people with DPN; the pain is often described as deep and aching or sudden, sharp, and stabbing – like an "electric shock." Patients may also experience severe weight loss, depression, and, in males, erectile dysfunction. Other symptoms include a constant burning discomfort in the feet, numbness of the feet, and unsteadiness resulting from disturbed proprioception and abnormal muscle sensory function (Boulton et al., 2004).

Cardiovascular disease (CVD) accounts for approximately 70% of all deaths among people with diabetes (Gu et al., 1998). Mortality from CVD is two to three times higher in men with diabetes compared to the rest of the male population, and as much as five times higher in women with diabetes (Almdal et al., 2004; Stamler et al., 1993; Kannel and McGee, 1979). On

average, individuals with diabetes tend to have an acute myocardial infarction 10-15 years earlier than the general population (Booth et al., 2003).

Among persons with diabetes, stroke is 2 to 4 times as common as found among persons without diabetes (Jorgensen et al., 1994; Jamrozik et al., 2000). Diabetes influences the occurrence and experience of stroke in several ways. The diabetic stroke patient is younger on average, recovers more slowly and is at a higher risk of death from a stroke than the non-diabetic stroke patient (Jorgensen et al., 1994). An estimated 37-42% of all strokes are attributable to the effects of diabetes alone or of diabetes in combination with hypertension (Kissela et al., 2005).

Persons with diabetes have a two- to four-fold increase in the rate of peripheral vascular disease (PVD), most often affecting the lower leg (Beckman et al., 2002). PVD can result in a significant range of functional impairments. At one end of the spectrum, there is painful walking. More seriously, when it is not possible to restore adequate blood supply to the limbs, amputation may be required. Approximately 40-60% of all lower limb amputations are performed in patients with diabetes (Apelqvist and Larsson, 2000).

In addition to the acute and chronic complications associated with diabetes, persons with type 2 diabetes are also at a higher risk of other co-morbidities, including hypertension, depression and ischemic heart disease (Broemeling, et al., 2005). In British Columbia, 31% of persons with diabetes also had hypertension, 11% were diagnosed with depression and 10% with ischemic heart disease. In Saskatchewan (Simpson, et al., 2003), 36% of health care expenditures for people with diabetes are attributable to major co-morbidities. The constellation of possible co-morbidities is consistent with evidence from the United States, which indicates that more than 40% of Americans with a chronic illness have at least one other co-existent chronic condition (Hoffman, et al., 1996). The probability of co-morbidities increases with the age of the individual

(Wolff et al., 2002). Evidence from the Netherlands suggests that, while approximately 21% of people with diabetes under the age of 65 have at least one co-morbidity, the proportion increases to 40% for those over the age of 65 (Schellevis et al., 1993).

Individuals with type 2 diabetes are also more likely to present with 'metabolic syndrome.' The World Health Organization (WHO, 1999) has defined the metabolic syndrome as the presence of at least two of the following criteria in an individual:

1. Central obesity (body mass index > 30 kg/m^2 and / or a waist-to-hip ratio > 0.90 m in males, > 0.85 m in females);
2. Dyslipidaemia (triglycerides ≥ 1.7 mmol/l and or HDL < 0.9 mmol/l in males, < 1.0 mmol/l in females or hypolipidemic treatment);
3. Arterial hypertension (≥ 140/90 mmHg or anti-hypertensive treatment);
4. Microalbumineria (30-299 mg/l).

The prevalence of individuals with the metabolic syndrome in the United States has increased rapidly during the last two decades in both adults and adolescents. In the year 2000, at least 27% of adults and 9.2% of adolescents were identified as having the metabolic syndrome (Ferranti et al., 2004; Ford et al., 2004).

Since the 1999 WHO definition, a number of other groups have attempted to define the metabolic syndrome, leading to substantial confusion and absence of comparability between studies (Alberti et al., 2005). To address this confusion, the International Diabetes Federation (IDF) convened a consensus group in 2004 consisting of all previous organizations involved in generating the previous definitions together with members from all IDF regions. This consensus group have defined the metabolic syndrome as the follows (Alberti et al., 2005):

1. The presence of central obesity defined by ethnic specific values for waist circumference;
2. Plus any two of the following:
    a. Raised triglycerides - > 150 mg/dL (1.7 mmol/L) and / or specific treatment for this lipid abnormality
    b. Reduced HDL-cholesterol - < 40 mg/dL (1.03 mmol/L) in men; < 50 mg/dL (1.29 mmol/L) in women and / or specific treatment for this lipid abnormality
    c. Raised blood pressure – Systolic ≥ 130 mm Hg; diastolic ≥ 85 mm/Hg and / or treatment of previously diagnosed hypertension
    d. Raised fasting plasma glucose – Fasting plasma glucose ≥ 100 mg/dL (5.6 mmol/L) and / or previously diagnosed type 2 diabetes. If above 5.6 mmol/L or 100 mg/dL, oral glucose tolerance test is strongly recommended, but is not necessary to define presence of the syndrome.

Despite differences in definitions, the general consensus is that the presence of the metabolic syndrome in patients with type 2 diabetes influences the risk of chronic complications (Isomaa et al., 2001; Hanna and Neary, 2004; Saely et al., 2005; Khunti et al., 2005). Bonora et al. (2003), for example, found that the presence of the metabolic syndrome in patients with type 2 diabetes was independently associated with an almost five-fold increase in cardiovascular disease. Sundstrom, et al. (2006) suggest that the metabolic syndrome can now be added as one of the established risk factors (in addition to smoking, diabetes, hypertension and serum cholesterol) for cardiovascular disease.

Due to the high level of both acute and chronic complications, as well as co-morbidities, the diabetes-related risk of mortality is significantly higher than mortality in the general

population. In people aged 15-34 years with type 1 diabetes, standardized mortality ratios are approximately 3.5 times higher than the general population (Wibell et al., 2001). Young people who have been admitted to hospital for diabetes have a nine times higher standardized mortality ratio than the general population, which includes a higher risk of death from suicide (Roberts et al., 2004). The age-adjusted relative risk of death from all causes in persons with type 2 diabetes is approximately 2 for men (Lutofo et al., 2001) and 3 for women (Hu et al., 2001), increasing to 5 and 7 respectively if the person with diabetes also has coronary heart disease. In terms of life expectancy, people without diabetes live 12-13 years longer than people with diabetes (Manual and Schultz, 2004).

In addition to increased risk of premature mortality, people with diabetes also suffer significant disability, with an estimated 20-50% reporting limitations in their activities (Songer, 1995). The health-related quality of life for people with diabetes has been estimated at between 0.6 - 0.9 on a scale from 0 to 1 with '1' representing perfect health and '0' representing death (Maddigan et al., 2000; Coffey et al., 2002). There is considerable variation depending on who is doing the evaluation (Landy et al., 2002). This scale has also been used to quantify the impact that major complications have on the individual's health-related quality of life (Clarke et al., 2002). Specifically, researchers estimated the impact of myocardial infarction at -0.055, blindness in one eye at -0.074, ischemic heart disease at -0.090, heart failure at -0.108, stroke at -0.164 and amputation at -0.280.

In summary, diabetes is one of the most serious of the chronic diseases, with significant multi-system complications if the disease is not well-managed. As a result, individuals with diabetes tend to have a shorter life expectancy, as well as significantly reduced quality of life compared to the general population.

2.2.2 The Effectiveness of Diabetes-Related Medical Care

While the morbidity and premature mortality associated with diabetes is significant, there is an important body of evidence which indicates that appropriate management of this chronic condition can delay and / or prevent the related complications.

The management of diabetes is aimed at reducing the acute and chronic complications associated with diabetes, primarily by maintaining the patient's blood glucose, blood pressure and lipid levels as close to normal as possible. This involves a combination of diet, smoking cessation, exercise, social support and drug therapy, the latter consisting of some combination of antihypertensive and cholesterol lowering agents, insulin injections or oral hypoglycaemic agents. In type 1 diabetes, the use of insulin therapy is always required, while normoglycaemia can sometimes be achieved in type 2 diabetes through diet and exercise alone, though concomitant oral hypoglycaemics or insulin are often also required.

The Diabetes Control and Complications Trial (DCCT) was a large, comprehensive diabetes clinical study conducted from 1983 to 1993 by the National Institute of Diabetes and Digestive and Kidney Diseases, based in the United States (DCCT Research Group, 1993). It involved 1,441 volunteers with type 1 diabetes from 29 medical centers in the United States and Canada. Volunteers had been diagnosed with diabetes for at least 1 year, but no longer than 15 years. This study compared the effects of two treatment regimens – standard therapy and intensive control – on the incidence of acute and chronic complications of diabetes. Volunteers were randomly assigned to each treatment group.

Intensive control involved self-testing blood glucose levels four or more times a day, four daily insulin injections or use of an insulin pump, frequent adjustment of insulin doses according

to food intake and exercise, a diet and exercise plan, and monthly visits to a health care team composed of a physician, nurse educator, dietician, and behavioural therapist.

This study found that intensive therapy with normalization of blood glucose levels reduced the risk of developing diabetic retinopathy by 76%, prevented the development and slowed the progression of diabetic kidney disease by 50%, and reduced the risk of nerve damage by 60% at 6.5 years of follow-up.

Follow-up research on this study population indicates that the beneficial results of this intensive control continued for a period of at least eight years, even though the difference in mean glycated haemoglobin (HbA1c) levels between the two treatment groups diminished over time, so that there was ultimately an average difference of only 0.2% during the follow-up period (DCCT Research Group, 2000, 2002, 2003). The authors concluded that "the current results reaffirm that intensive treatment of type 1 diabetes should be initiated as early as safely possible in order to provide strong and durable protection from the development and progression of diabetic microvascular disease" (DCCT Research Group, 2003, p. 2166).

The United Kingdom Prospective Diabetes Study (UKPDS Group, 1998a) followed 1,148 patients with hypertension and type 2 diabetes (enrolled between 1987 and 1991) for an average of nine years. Patients were randomly allocated to a tight control of blood pressure group (with a goal of < 150/85 mm Hg) and a less tight control of blood pressure group (with a goal of <180/105 mm Hg). Patients visited study centres every 3-4 months. At each visit, plasma glucose concentration, blood pressure, and body weight were measured. Treatments to control blood pressure and blood glucose concentration were assessed and adjusted if target values were not met.

The results of the UKPDS indicate that the tight blood pressure control group experienced a 32% reduction in death related to diabetes, a 44% reduction in stroke, a 56% reduction in the risk of heart failure, a 37% reduction in microvascular disease, and a 47% reduced risk of deterioration of visual acuity.

This study also found a strong relationship between glucose levels and subsequent cardiovascular events. For every 1% reduction in glycated haemoglobin (HbA1c), the authors observed a 14% drop in the incidence of acute myocardial infarction (AMI) and a 16% drop in heart failure rates.

After reviewing the new information from the United Kingdom Prospective Diabetes Study, the American Diabetes Association stated that "it is time for all health professionals to treat diabetes aggressively. It is also time for patients to take their diabetes with the utmost seriousness. And it is incumbent upon the health care system to provide the necessary resources for both to be successful. Compromise or acceptance of a disadvantageous and dangerous status quo in people with diabetes should not be tolerated any longer" (Genuth et al., 2003, p. S32).

A study in Denmark randomly assigned 80 individuals with type 2 diabetes to a “targeted, intensified, multifactorial intervention” and 80 to receive conventional treatment (Gaede et al., 2003). The intervention group received a stepwise implementation of behaviour modification (diet, exercise, and smoking cessation) and pharmacologic therapy that targeted hyperglycaemia, hypertension, dyslipidemia, and microalbuminuria. The intervention group saw significant improvements (compared to the conventional treatment group) in their glycosylated haemoglobin values, systolic and diastolic blood pressures, serum cholesterol, triglyceride level and urinary albumin excretion rate at the end of the 7.8 year follow-up. At the end of that time period, 44% of patients in the conventional therapy group had one or more cardiovascular events

(death from cardiovascular causes, nonfatal myocardial infarction or stroke, coronary- or peripheral-artery revascularization, or amputation as a result of ischemia) compared to only 24% in the intervention group.

Solomon (2003), commenting on the study by Gaede et al. (2003) notes that this study "provides the best evidence to date of the magnitude of the benefits that can be derived from instituting several interventions". But even with the intensive interventions offered in the Denmark study, targeted blood pressure and blood glucose levels were only infrequently achieved. Less than half of the patients in the intensive therapy group achieved target systolic blood pressure levels while less than a fifth achieved targeted glycosylated haemoglobin levels. As noted by Solomon (2003), "although these findings point to the difficulty of achieving the targets in the real world, they also suggest the possibility of even greater benefits if the targets can be met more frequently."

Despite significant strides in the treatment of diabetes, the patients themselves must invest a considerable amount of time, energy and resources in dealing with diabetes, presenting a constant challenge for people with the disease. The 2nd edition of *Diabetes in Canada* (Health Canada, 2002a) notes that "diabetes exerts a significant effect on the quality of life of those with the disease. The continuous need to monitor intake (in terms of timing, type and amount of food), take medications (whether pills or insulin injections), monitor blood glucose, and anticipate and plan for activities that may affect diabetes control can put a severe strain on daily life" (p. 10).

It is perhaps not surprising then that target blood glucose and blood pressure levels are consistently hard to achieve, even in clinical trials. The difficulty in consistently achieving targets noted in the study by Gaede and colleagues (2003) has been confirmed by a number of

other studies (Menard, et al., 2005; Rothman and Elasy, 2005; Karter et al., 2005). Karter et al. (2005) found that just 18% of the patients in their study of new antihyperglycaemic therapies reached a target HbA1c of ≤7.0%. Menard et al. (2005) found that even after a year of intensive multitherapy intervention most patients were substantially below the goal of 100% adherence. Just 35% of patients in the intervention arm achieved the goals of HbA1c of ≤7.0%, 64% reached a diastolic blood pressure of < 80 mm Hg, 53% reached a low-density lipoprotein cholesterol level of < 2.5 mmol/L and 44% achieved triglyceride levels of < 1.5 mmol/L. It should be noted that these levels were significantly better than the no intervention control group (8%, 37%, 20% and 14%, respectively for the control group). Just six months after the completion of the research trial and the return to usual care, however, the benefits achieved during the trial had vanished; specifically, as noted in an editorial by Rothman and Elasy (2005), "there were no longer statistically significant differences in haemoglobin A1c concentrations, blood pressure or triglyceride levels between the intervention and control groups."

In summary, the considerable complications associated with diabetes can be delayed and /or minimized with appropriate management. The most successful outcomes are achieved when there is a strong partnership between the patient and the clinical team. When clinical vigilance and patient accountability are relaxed, however, the research suggests that target levels of blood glucose and blood pressure are difficult to maintain.

2.2.3 The Economic Impact of Diabetes-Related Illness

The current economic burden of diabetes is substantial, at least partly due to the high level of complications faced by patients whose chronic condition is not well-managed. In 1992, people with diabetes accounted for 15% of total US health care expenditures, even though they constituted only 4.5% of the total population (Rubin et al., 1994). Bagust and colleagues (2001)

have estimated the lifetime health care costs for patients with diagnosed type 2 diabetes to be more than twice that for an equivalent non-diabetic population. The cost to health plans in the US increases significantly with every 1% increase in HbA1c levels above 6% (Gilmer et al., 1997). Moss et al. (1999) found that increases in HbA1c levels positively predicted hospitalizations among people with diabetes. In contrast, factors in the diabetic population that were not significantly associated with hospitalizations included age, gender, systolic and diastolic blood pressures, body mass, smoking status, and alcohol consumption.

According to a study commissioned by the American Diabetes Association (2003), diabetes was estimated to cost the US economy $132 billion in 2002. Direct medical expenditures are estimated at $91.8 billion, which includes $23.2 (25%) billion for diabetes care, $24.6 (27%) billion for chronic complications attributable to diabetes, and $44.1 (48%) billion for excess prevalence of general medical conditions. Indirect costs, totalling $39.8 billion, were associated with lost workdays, restricted activity days, premature mortality, and permanent disability due to diabetes.

The authors note that the $132 billion "likely underestimates the true burden of diabetes because it omits intangibles, such as pain and suffering, care provided by nonpaid caregivers, and several areas of health care spending where people with diabetes probably use services at higher rates than people without diabetes (e.g., dental care, optometry care, and the use of licensed dieticians). In addition, the cost estimate excludes undiagnosed cases of diabetes" (ADA, 2003, pg 917). After adjusting for differences in age, gender, and race/ethnicity, people with diabetes utilized approximately 2.4 times the health care resources of someone in the general population.

Estimates of the economic burden of diabetes in Canada are quite variable. A study by Health Canada (2002b) suggests that the economic burden of diabetes in Canada was $1.6 billion

(Cdn $) in 1998. Health Canada acknowledges that this is a very conservative estimate, one which does not include physician costs, costs associated with the complications of diabetes, costs borne by patients and costs associated with short-term disability as well as the value of time lost from work and leisure activities by family members or friends who care for the patient. An alternate estimate from Health Canada (2002a), simply based on the relative population sizes of the two countries, suggests that the true economic burden may be as high as 10% of the U.S. figure, or $13.2 billion in 2002.

Simpson et al. (2003) estimated the direct health care costs (hospitalizations, physician services and prescription drugs) for the 3.6% of Saskatchewan's population with diagnosed diabetes to be $143.3 million in 1996, or approximately 15% of total expenditures in these three areas that year. These direct costs averaged $3,524 per person per year. Ohinmaa et al. (2004) used this Saskatchewan data, with the addition of day surgery and outpatient dialysis costs, to estimate the direct health care costs in Canada for people with diagnosed diabetes to be $4.66 billion in 2000. Dawson et al. (2002) used a broader approach in estimating the economic burden of diabetes in Canada, including estimated costs for undiagnosed cases as well as indirect costs (mortality related productivity losses). Their estimate of the total economic burden of diabetes in Canada in 1998 was between US$4.76 and $5.23 billion.

Laditka and co-workers (2001) compared the resource use of people with diabetes to those without diabetes in an employer-based population in Ohio in 1996. The commercial health insurer in that state had an enrolment of approximately 828,000 employed individuals, of whom 1.6% had diabetes. This 1.6% of the population generated 9.4% of the insurer's costs. Total annual per capita costs for the non-diabetic population were $909, compared to $5,659 for the diabetic cohort. More specifically, the diabetic population used inpatient resources at a rate 4.8

times that of the non-diabetic population, after adjusting for the age and gender differences in the two populations. Rates of resource use were also 2.5 times higher for outpatient facility encounters, 2 times higher for emergency department visits, 2.4 times higher for physician office visits, 3 times higher for physician consultation visits and 2.8 times higher for ancillary services such as laboratory and radiology tests.

Several groups within Canada have examined aspects of resource use by persons with diabetes compared to the general population. Research on the level of family physician utilization in Winnipeg, Manitoba indicates that persons with diabetes see their family physician just over two times as often as the general population (Watson et al., 2003). In Ontario, patients with diabetes visited a physician or optometrist 2.2 times more frequently in 2000/01 compared to patients without diabetes (Chan and Harju, 2003).

Klarenbach and Jacobs (2003) provide a comparison of health resource utilization in Canada and the US. They found that patients with diabetes in Canada were more likely to have contact with a general physician and an eye specialist, but were less likely to have contact with other medical specialists compared to their American counterparts.

Several studies provide information on the average annual medical care costs by people with diabetes. Not surprisingly, hospitalizations create a huge financial burden on society. In a European study, the average annual direct medical cost for people with diabetes was estimated at €2,515 (Jönsson, 2002). Of this amount, 53% was for hospitalization, 24% for ambulatory care and 23% for drugs. Simpson et al. (2003) estimated the health care expenditures for people with diagnosed diabetes in Saskatchewan in 1996. Average costs per capita were $3,524 consisting of $1,889 (53.7% of the total) in hospitalization costs, $836 (23.8%) in prescription drug costs,

$583 (16.6%) in physician services costs, $115 (3.3%) in dialysis costs and $96 (2.7%) in day surgery costs.

The juvenile burden is similar to that of adults. Hospitalization rates in children with diabetes are approximately 3 to 7 times that of their peers (Aro et al., 1994; Icks et al., 2001).

Broemeling and co-authors (2005) examined resource use in adults with diagnosed diabetes in British Columbia in 2000/01. In their study, the authors used Adjusted Clinical Groups (ACGs) to allocate people with diabetes into the following five groups based on co-morbidity:

- No co-morbidity
- Low co-morbidity (2-3 additional conditions ranging from minor acute and time-limited conditions to chronic, medically unstable, psychosocial, and major acute conditions)
- Medium co-morbidity (4-5 additional conditions)
- High co-morbidity (6-9 additional conditions)
- Very high co-morbidity (10+ additional conditions)

Similar to other studies, the authors found that adults with diabetes used 2.4 times the health care resources compared to the general adult population. Their analysis revealed that the level of resources used varied significantly based on the level of co-morbidity. The healthiest group of individuals with diabetes, those with no co-morbidity, used only 0.1 times the level of resources. The group with low co-morbidity used 0.6 times the resources, and those with medium co-morbidity used 1.2 times the resources. Most significantly, the diabetic population with high co-morbidity used 3.9 times the resources and those with very high co-morbidity used

11.5 times the resources. Thirty-two percent of the diabetic population were in the high or very high co-morbidity groups.

Williams et al. (2002) used disease specific complications when assessing the impact of complications on the costs of type 2 diabetes. They divided people with type 2 diabetes into the following four broad categories of complication status:

1. No complications.
2. One or more microvascular complications only. Microvascular complications include foot ulcer, amputation, retinopathy, photocoagulation, vitrectomy, blindness in one or both eyes, microalbuminuria, nephropathy, dialysis, renal transplant and neuropathy.
3. One or more macrovascular complications only. Macrovascular complications include angina, myocardial infarction, heart failure, percutaneous transluminal coronary angioplasty, coronary artery bypass graft, transient ischemic attack, stroke and peripheral vascular disease.
4. One or more of each of microvascular and macrovascular complications.

A patient with no complications cost €1,505 in direct medical costs per year. Compared to a patient with no complications, the presence of microvascular complications added 70% to these costs, macrovascular complications added 100% to these costs and the presence of both micro and macrovacsular complications increased the costs by 330% (€5,226).

In summary, the economic costs, both direct and indirect, associated with diabetes are high, largely due to the serious complications associated with the condition if it is not appropriately managed. In both Canada and the United States, average health care resource use for an individual with diabetes is at least two times that of the general population, though this

ratio is highly dependent on the presence of co-morbidities or complications. Over half of the average annual direct care costs are due to hospitalizations.

2.3 Recommended Clinical Procedures

The complications and costs associated with diabetes are significant, yet both can be substantially reduced if the disease is well-managed, as will be summarized in section 2.5 (*Potential for Savings Associated with Improving Planned Management*) of this chapter. But can one identify and track ideal management? Clinical practice guidelines (CPGs) are one option for summarizing and distributing best practice information in an accessible format. As knowledge on best practices for a specific disease evolves, CPGs can be modified to take the new information into account.

The following section will provide some background on CPGs and review the evolution of CPGs for diabetes in Canada and British Columbia.

2.3.1 Clinical Practice Guidelines

Woolf (1990) has defined practice guidelines as "the official statements or policies of major organizations and agencies on the proper indications for performing a procedure or treatment or the proper management for specific clinical problems" (p. 1812). The most commonly used definition of clinical practice guidelines is that provided by Field and Lohr (1992): "(S)ystematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (p. 2). Guidelines are developed based on the best available evidence at the time of their development. As noted earlier, as knowledge on best practices for a specific disease evolves, CPGs can be modified to take the new information into account.

Guidelines have been used in one form or another for over 50 years in medicine, being described variously as practice standards, recommendations, protocols, policies, parameters, options, care maps, care pathways, and so on (Woolf, 1990, 1995; Woolf et al., 1999). In the United States, the federal government created a new agency in 1989, the Agency for Health Care Policy and Research (AHCPR), whose role, in part, was to develop CPGs. The AHCPR was given the mandate to develop three initial guidelines by January 1, 1991 (Woolf, 1990). Interest in CPGs at that time extended beyond North America to Australia and New Zealand, as well as to countries in Europe and Africa (Woolf et al., 1999). In the Netherlands, for example, guidelines have been worked on since 1987 by the Dutch College of General Practitioners, with the resulting CPGs figuring prominently in Dutch health policy. By 1993, over 1,500 CPGs had been developed in the US alone (Woolf, 1995).

The rapid proliferation of CPGs in the late 1980s and 1990s was driven by at least three converging areas of research (Field and Lohr, 1992). The first involves the documentation of unexplained geographic variation in medical practices. Dating back to 1969, studies by Wennberg and others (Lewis, 1969; Wennberg and Gittelsohn, 1973; McPherson et al., 1982; Chassin et al., 1986; Wennberg et al., 1987; Perrin et al., 1989; McMahon et al., 1989) reported large, unexplained variances in the receipt of medical care by patients living in different geographic regions. While the reasons for these variances are not fully known, one suggestion has been that they may be explained in part by clinician uncertainty about the proper indications for procedures (Wennberg et al., 1977). If this is the case, then the provision of CPGs would be a potential approach to reducing this uncertainty (Wennberg, 1984).

The second area of research is on the inappropriate use of interventions. The most important work in this area was completed by Chassin and colleagues (1987), in which 5,000

medical records were reviewed to measure the appropriateness of three procedures. Their findings suggested that 17% of coronary angiography, 32% of carotid endarterectomy, and 17% of upper gastrointestinal tract endoscopy procedures were inappropriate. Findings such as this have fuelled speculation about the inappropriate use of a broader range of medical procedures.

The third area of research led to uncertainty about the health outcomes achieved by the use or non-use of various services and interventions (Eddy, 1984; Eddy and Billings, 1988; Brook, 1989; Brook et al., 1986; Roper et al., 1988). Research on the effectiveness, let alone the cost-effectiveness, of many health care services and procedures did not exist, or was incomplete. In response, Roper and Hackbarth (1988) encouraged the Health Care Financing Agency in the US to "purchase value, the optimal mix of high quality and reasonable cost" (p. 91) and to increase funding for research on effectiveness and the promotion of quality care.

The perception that the costs of medical care, particularly in the US, were spiralling out of control in the 1980s, together with the three research streams noted above, led to a powerful motivation for the implementation of CPGs. It was hypothesized that the systematic combination of scientific evidence and clinical judgment would lead to recommendations for appropriate care that would be embraced by physicians and their patients alike, leading to better health outcomes and lower health care costs. In essence, CPGs were an attempt to control costs while improving quality of care, risk management, and patient outcomes (Field and Lohr, 1992).

The five major purposes of CPGs as identified by Field and Lohr (1992) are:

- To assist in clinical decision-making by patients and practitioners
- To educate individuals or groups
- To assist in assessing and assuring the quality of care
- To guide the allocation of resources for health care

- To reduce the risk of legal liability for negligent care.

While a myriad of CPGs have been developed, the implementation of their recommendations into every day practice has not been smooth. In 1988, Eddy and Billings (p. 20) warned:

> To achieve high-quality medical care, we must succeed at three main tasks. First, we must determine just what practices constitute high-quality care. This involves analyzing evidence of the effectiveness, risks, and costs of various medical practices, and designing standards that define appropriate practices. The second task involves monitoring existing practices to compare them against the accepted standards. The third involves changing the behaviour of practitioners to ensure that the care actually delivered meets the standards. Failure at any of these tasks will threaten the quality of care people actually receive.

2.3.2 Clinical Practice Guidelines for Diabetic Care

2.3.2.1 Guideline Development in Canada

National clinical practice guidelines for diabetes were first developed and distributed in Canada in September, 1992 (Tan et al., 1992), and then updated in 1998 (Meltzer et al., 1998) and again in 2003 (Canadian Diabetes Association, 2003).

The 1992 guideline (Tan et al., 1992) were developed by an expert committee of volunteers consisting of specialist and family physicians, nurse educators, dieticians and a lawyer. This group prepared position papers which were then reviewed by 38 other health professionals prior to preparing a second draft of the guidelines for discussion at a public consensus conference. The final version of this early CPG was published in the September, 1992 issue of the Canadian Medical Association Journal.

In 1998, the Canadian Diabetes Association's Clinical and Scientific Section revised the 1992 CPG, incorporating new research developments (Meltzer et al., 1998). These guidelines were based on a series of recommendations, each recommendation graded according to the level

of supporting evidence. The process for developing the 1998 CPG was similar to the one used in 1992 with an expert committee preparing background papers for synthesis into a larger report, which was then reviewed by external experts and discussed at a public forum.

The 2003 CPG (Canadian Diabetes Association, 2003) was developed in response to a number of important new research findings (Hu et al., 2001; Tuomilehto et al., 2001; Knowler et al., 2002). The new results included those from the UKPDS (UKPDS Group, 1998) and follow-up studies on the DCCT population (DCCT Research Group, 2000).

The authors of the 2003 CPG generally followed the process established for the earlier versions of the diabetes CPG, with the following key principles (Canadian Diabetes Association, 2003):

- Each recommendation had to address a clinically important question related to one or more of the prevention, detection or management of diabetes mellitus and its sequelae.
- Whenever possible, each recommendation had to be justified by the strongest clinically-relevant empirical evidence that could be identified; the citation(s) reporting this evidence had to be noted adjacent to the relevant guideline.
- A summary of the strength of this evidence, based on prespecified criteria from the epidemiological literature and other guidelines, had to be noted.
- The evidence had to be incorporated into a recommendation that was assigned a grade based on the available evidence, evaluating both its strength, and its applicability.
- Guidelines based on biological or mechanistic reasoning, expert opinion, or consensus had to be explicitly identified and graded as such (p. S4).

The authors acknowledged that CPGs have often fallen short of their intended goals. In order to improve participation, they developed a dissemination strategy which included a searchable web-based version of the guidelines, summary articles published in a variety of professional journals, and messages targeted to people with diabetes and the general public.

2.3.2.2 Guideline Development in British Columbia

In British Columbia, CPGs are developed under the direction of the Guidelines and Protocols Advisory Committee (GPAC), jointly sponsored by the B.C. Medical Association (BCMA) and the Ministry of Health. The GPAC is co-chaired by the BCMA and the Medical Services Plan (MSP). GPAC chooses topics, approves draft guidelines for external review, and approves final guidelines for submission to the Medical Services Commission (MSC) for review and adoption in B.C. It also coordinates strategies to implement and evaluate guidelines.

The decision about which guidelines to develop is based on high volume and / or costs of the specific medical condition, high variability in practice patterns, opportunities for improvement in practice, and the support and interest of physicians.

The guideline development process in B.C. involves a literature search, draft guidelines, multiple consultations with experts and external reviews. Final approval of the guidelines is made by the B.C. Medical Association and the Medical Services Commission. Published guidelines are reviewed every two years, or even earlier if new evidence warrants. The latest version of the CPG for diabetes care was published in January, 2004.

2.3.2.3 Diagnosis of Diabetes

The diagnostic criteria used in determining whether an individual has diabetes are summarized in section 2.1 above. A comparison of the CPGs developed for diabetes in Canada reveal that these criteria have changed since 1992 due to the availability of new research evidence (see Table 2-1 below).

Table 2-1: Diagnostic Criteria for Diabetes in Nonpregnant Adults Based on the Canadian Diabetes Clinical Practice Guidelines

	1992	**1998** (5)	**2003** (7)
FPG (mmol/L)	>7.8 mmol/L (2)	≥7.0 mmol/L	≥7.0 mmol/L
Casual (1) **PG (mmol/L)**	>11.1 mmol/L (3)	≥11.1 mmol/L (6)	≥11.1 mmol/L (8)
2hPG in a 75-g OGTT (mmol/L)	>11.1 mmol/L (4)	≥11.1 mmol/L	≥11.1 mmol/L

Notes

(1) *Casual = any time of the day without regard to the interval since the last meal*
(2) *On at least two occasions*
(3) *Plus symptoms and signs of diabetes (increased thirst, polydipsia, polyuria, polyphagia, weight loss, fatigue, blurred vision, etc.)*
(4) *Observed on at least two occasions in addition to a FPG value of > 7.8 mmol/L.*
(5) *A confirmatory test must be done on another day in all cases in the absence of unequivocal hyperglycemia accompanied by acute metabolic decompensation.*
(6) *Plus symptoms of diabetes. The classic symptoms of diabetes include fatigue, polyuria, polydipsia and unexplained weight loss.*
(7) *A confirmatory laboratory glucose test (an FPG, casual PG or a 2hPG in 75-g OGTT) must be done in all cases on another day in the absence of unequivocal hyperglycemia accompanied by acute metabolic decompensation*
(8) *Plus symptoms of the disease. Classic symptoms of the disease = polyuria, polydipsia and unexplained weight loss.*

Abbreviations

FPG = fasting plasma glucose, fasting is defined as no caloric intake for at least 8 hours
PG = plasma glucose
2hPG = 2-hour plasma glucose
OGTT = oral glucose tolerance test

The medical community has become increasingly aware of the dangers of high blood glucose levels, which is reflected in the changes to the CPGs. In 1992, an individual with a fasting plasma glucose level >7.8 mmol/L was considered to have diabetes. The threshold was lowered to ≥7.0 mmol/L in the 1998 guidelines. It is important to note that while the 2003 version of the guidelines maintains the 7.0 mmol/L level, they have added that blood glucose levels below this threshold also have clinical consequences. The authors of the 2003 guideline suggest the term "impaired fasting glucose" for any individual with a fasting plasma glucose level between 6.1 and 6.9 mmol/L (Canadian Diabetes Association, 2003).

2.3.2.4 Optimal Targets for the Control of Diabetes

A comparison of all the three versions of the Canadian and the current British Columbia CPGs indicates that important targets for the control of blood glucose, blood pressure and cholesterol levels have all changed since 1992 (see Table 2-2 below). The pattern has been toward lowering the test criterion to enable earlier detection and broader inclusion.

Table 2-2: Optimal Targets for the Control of Diabetes Based on the Canadian and British Columbia Diabetes Clinical Practice Guidelines

	1992	1998	2003	BC 2004
Plasma glucose level (mmol/L)				
Pre-meal	4.0 - 7.0	4.0 - 7.0	4.0 - 7.0	4.0 - 7.0
Post-meal	5.0 - 10.0	5.0 - 11.0	5.0 - 10.0	5.0 - 10.0
Glycosylated hemoglobin level (% of upper limit)	< 110	≤ 115		
Equivalent HbA1c assay		< 7.0%	< 7.0%	< 7.0%
Cholesterol level				
LDL (mmol/L)	< 3.4 (1)			
Diabetes and either CAD or 3 or more other risk factors		< 2.5 (2)		
Diabetes and 2 other risk factors (6)		< 3.5 (3)		
Diabetes and 1 other risk factor		< 4.0 (4)		
Diabetes and no other risk factors		< 5.0 (5)		
High risk (7)			< 2.5	< 2.5
Moderate Risk (8)			< 3.5	< 3.5
Total (mmol/L)	< 5.2 (1)			
HDL (mmol/L)	>1.1 (1)			
Total:HDL cholesterol ratio (mmol/L)				
Diabetes and either CAD or 3 or more other risk factors		< 4.0 (2)		
Diabetes and 2 other risk factors		< 5.0 (3)		
Diabetes and 1 other risk factor		< 6.0 (4)		
Diabetes and no other risk factors		< 7.0 (5)		
High risk (7)			< 4.0	< 4.0
Moderate Risk (8)			< 5.0	< 5.0
Triglyceride level (mmol/L)	< 1.7 (1)		(9)	
Diabetes and either CAD or 3 or more other risk factors		< 2.0 (2)		
Diabetes and 2 other risk factors		< 2.0 (3)		
Diabetes and 1 other risk factor		< 2.0 (4)		
Diabetes and no other risk factors		< 3.0 (5)		
BMI (under 65 years of age)	< 25	"healthy"	18.5 - 24.9	18.5 - 24.9
Blood pressure (mm Hg)	< 140/90 (10)	< 130/85	< 130/80	< 130/80
Microalbumin / Creatinine Ratio (ACR)				
Males		< 2.0	< 2.0 (11)	< 2.0
Females		< 2.8	< 2.8 (11)	< 2.8
Estimated Glomerular Filtration Rate (eGFR)			≥ 90 mL/min	≥ 90 mL/min

Notes

(1) *Should be adjusted for other risk factors. Less strict targets may be appropriate for older patients with limited life expectancy*

(2-5) *All 3 target values (LDL, Total:HDL and triglyceride level) must be achieved.*

(6) *Major risk factors include family history of premature CAD, smoking, hypertension, low HDL (≤0.9 mmol/L) and age over 30 years in both men and women*

(7) *Most patients with diabetes*

(8) *Younger age and shorter duration of diabetes and no other complications of diabetes and no other risk factors for vascular disease*

(9) *"There are very little clinical data to support recommendations on TG levels…it is uncommon for a patient to have a significant elevation in serum TGs with LDL-C and TC:HDL-C at target levels. Thus, in order to simplify the lipid targets, a specific TG target level is not provided" (pg. S59).*

(10) *"For patients with diabetic nephropathy, it has been suggested that optimal blood pressure should be 130/80 to 135/85 mm Hg; however, conclusive evidence is lacking" (pg. 700)*

(11) *A patient is considered to have nephropathy at these levels if confirmed on at least 2 out of 3 tests taken at least one week apart.*

Abbreviations

LDL = low-density lipoprotein
HDL = high-density lipoprotein
BMI = body mass index
CAD = coronary artery disease
TG = triglyceride
Hg = Hemoglobin

In the 1992 guidelines, a glycated haemoglobin level of <110 (% of upper limit) was considered appropriate. Six years later this was modified to ≤115 (% of upper limit), or the equivalent haemoglobin A1c of <7%. Recommended cholesterol levels were initially set at a total cholesterol level of <5.2 mmol/L and a high-density lipoprotein (HDL) level of >1.1 mmol/L. By 2003, the recommended Total:HDL level for high risk patients was <4.0 and the level for moderate risk patients was <5.0. Finally, the recommended blood pressure was steadily adjusted downward from <140/90 in 1992 to <130/80 in 2003. These targets have been well supported by research such as that by the DCCT (1993, 1995, 2000, 2002, 2003) and the UKPDS (1998b). The medical community is in agreement that tight control of blood glucose, cholesterol and blood pressure levels results in clinically important reductions in the complications associated with diabetes.

The 2003 guidelines recommend even more aggressive targets for some patients. Specifically, a haemoglobin A1c level of ≤ 6% is recommended for patients in whom it can be safely achieved. Unfortunately, the risk of severe hypoglycaemia was three times higher among participants receiving intensive therapy. Therefore, "normoglycemia may not be an appropriate goal in individuals with either type 1 diabetes or type 2 diabetes who are at risk for severe hypoglycaemia" (DCCT, 1993; p. S18).

2.3.2.5 Recommended Diagnostic Procedures to Assess the Ongoing Control of Diabetes

In order to determine whether the optimal levels of control are being achieved, the guidelines outline a set of recommended diagnostic tests to be performed on a periodic basis. These include an HbA1c assay, which determines how much glucose has bound to the A1c form of haemoglobin in a process called glycosylation. The identified value reflects how much

glucose has been in the blood during the past average 120-day lifespan of red cells. The three month time period for this test was chosen to reflect the continuous monitoring of blood glucose levels given the average life-span of a red blood cell (Saudek, et al., 2006).

A lipid profile was recommended every six months in 1992, with the frequency reduced to every 1-3 years in subsequent CPG. The 2003 Canadian Guidelines note that "a fasting lipid profile (TC, HDL-C, TG and calculated LDL-C) should be conducted at the time of diagnosis of diabetes and then every 1 to 3 years as clinically indicated….More frequent testing should be done if treatment for dyslipidemia in initiated" (p.S60). The 2003 Canadian Guidelines suggested that most patients with diabetes fell into the high risk of a vascular event category and that treatment should be initiated if LDL-C <2.5 and TC:HDL-C <4.0. For patients with a moderate risk (e.g. "younger age and shorter duration of diabetes and no other complications of diabetes and no other risk factors for vascular disease"), treatment should be initiated if LDL-C <3.5 and TC:HDL-C<5.0. The recommended treatment approach, in addition to lifestyle modifications, is to prescribe a statin with the possibility of prescribing a fibrate for higher risk patients. The use of statins as the drug of choice to lower cholesterol levels was based on the results of the Heart Protection Study (Heart Protection Study Collaborative Group, 2002; Yusuf, 2002) which found that adding a statin (simvistatin) to existing treatments produced a substantial reduction in vascular events in high-risk patients, regardless of their initial cholesterol concentrations. Finally, the Canadian Guidelines suggest that "when monotherapy fails to achieve lipid targets, the addition of a second drug from another class should be considered" (p. S60).

The measurement of blood pressure was supposed to take place at least every six months in the 1992 guidelines, but has subsequently been recommended to take place at every physician

visit. The patient care plan included in the 2003 Canadian Guidelines indicates that blood pressure should be measured at least four times per year (p.S123).

An eye exam is recommended at least once every two years, more frequently if the patient has retinopathy. The 2003 Canadian Guidelines note that "in people with type 1 diabetes, screening and evaluation for retinopathy by an experienced professional should be performed annually 5 years after the onset of diabetes in individuals ≥15 years of age" (p.S77). Furthermore, "in people with type 2 diabetes, screening and evaluation for retinopathy by an experienced professional should be performed at the time of diagnosis. The interval for follow-up assessments should be tailored to the severity of the retinopathy. In those with no or minimal retinopathy, the recommended interval is 1 to 2 years" (p. S77).

Measurement of urinary microalbumin should take place at diagnosis and at least annually thereafter (see Table 2-3 below). Microalbuminuria is associated with a level of 30 – 299 μg/mg creatinine while macroalbuminuria is associated with levels of 300 or higher (American Diabetes Association, 2005). Because of the variability in urinary albumin excretion, two or three specimens collected over a three to six month period should show abnormal results before a patient is considered to have crossed one of these diagnostic thresholds.

The 2003 Canadian Guidelines note that in people with type 2 diabetes who have been diagnosed with nephropathy, the preferred treatment is an ACE inhibitor or ARB if the creatinine clearance is >60 mL/min or an ARB if the creatinine clearance is ≤60 ml/min. These guidelines suggest that serum creatinine and potassium levels be checked "within 2 weeks of initiation of therapy and periodically thereafter" (p. S69). The American Diabetes Association (2005) notes that "the role of annual microalbumin assessment is less clear after diagnosis of microalbuminuria and institution of ACE inhibitor or ARB therapy and blood pressure control.

Most experts, however, recommend continued surveillance to assess both response to therapy and progression of disease."

Table 2-3: Recommended Diagnostic Procedures to Assess the Ongoing Control of Diabetes Based on the Canadian and British Columbia Diabetes Clinical Practice Guidelines

	1992	1998	2003	BC 2004
Blood Glucose Control Over Time				
HbA1c assay	at least every 6 months	every 3-4 months if on insulin, otherwise every 6 months	approximately every 3 months	every 3 months
Patient Blood Glucose Monitoring	essential for patients taking insulin	essential for all type 1 diabetes, pregnant women with diabetes and insulin-treated type 2 diabetes	type 1 diabetes - at least 3 times per day, most with type 2 - at least once per day	regular as appropriate
Blood Pressure	at least every 6 months	at every visit	at every visit	at every visit
Lipid Profile	at least every 6 months, if dyslipidemia then every 4 months	every 1-3 years	every 1-3 years	every 1-3 years
Foot Examination	at least annually	at least annually, more often for those at high risk	at least annually, more often for those at high risk	at least annually
Nephropathy				
Screen for macroscopic protein & non-renal diseases with dipstick				
If protein-negative, measure ACR		annually for all type 2 and type 1 with five + years duration	annually for all type 2 and type 1 with five + years duration	at least annually
Measure SCr (currently lab will report eGFR)	at least annually, 5+ years diabetic with proteinuria measure urinary protein excretion, without proteinuria measure microalbuminuria.	if no albuminuria, annually for people over 15 with a 5 year historyof type 1 and all type 2	annually if no albuminuria, otherwise at least every six months	at least annually
Neuropathy	check annually for symptoms	check annually for symptoms	check annually for symptoms	check annually for symptoms
Retinopathy				
Retinal eye exam	if patient has retinopathy, at least annually	based on the severity of the retinopathy, if no retinopathy then every 2 years	based on the severity of the retinopathy, if no retinopathy then every 2 years	every 1-2 years

Abbreviations

ACR = Albumin to creatinine ratio
SCr = Serum creatinine
eGFR = Estimated Glomerular Filtration Rate

In addition to conducting diagnostic procedures, physicians are encouraged to assess and discuss self-management challenges, encourage patient blood glucose monitoring, provide counsel on issues of smoking, weight control and exercise, ensure the patient is vaccinated for influenza and pneumonia, and prescribe medications as required.

The 2004 BC CPG includes the following practice points for the care of a patient with diabetes:

- Minimizing symptomatic hyperglycaemia or hypoglycaemia overrides the stated target levels for A1c.
- More frequent lipid measurement is required for patients receiving treatment for dyslipidemia.
- Most adults with diabetes are at high risk of cardiovascular disease.
- Rigorous control of blood pressure has been shown to reduce the risk of complications and mortality rates.
- Co-existing depression is common in patients with diabetes. Diagnose and treat as appropriate.

2.3.3 Recommended Clinical Procedures

As previously discussed, achieving ideal blood glucose and pressure levels is difficult in an optimal research environment and even more difficult in a usual care setting. One organization that has had some success in the United States is the Veteran's Health Administration (VHA). Patients from the VHA score significantly higher than a national sample for overall quality of care, chronic disease care and preventative care (Asch et al. 2004; Greenfield and Kaplan, 2004). The VHA has developed more achievable targets that are strongly linked to health outcomes and then rewarded physicians for process measures (e.g. testing for HbA1c, cholesterol and blood pressure levels) with less focus on whether or not these levels are achieved. They established a series of priorities for the medical care of high risk patients. Their thresholds for blood glucose (HbA1c <9.0-9.5%), blood pressure (<135-140/80-85 mmHg) and

LDL cholesterol (<130-140mg/dl) were less stringent than the levels recommended in CPGs (Hayward et al., 2004).

The VHA program tends to focus on "'tightly linked' quality measures in which the clinical interventions or process is strongly and directly linked to patient outcomes, an actionable process is measured, and a high-risk population is targeted" (Hayward et al., 2004). By focussing on 'tightly linked' clinical interventions, providers receive credit for appropriate care "regardless of the severity of their patient population" (Hayward et al., 2004). Included in these 'tightly linked' clinical interventions for diabetes are the measurements of blood sugar, blood pressure and cholesterol levels.

The Organization for Economic Co-operation and Development (OECD) has taken a systems approach in determining which indicators to use in assessing the quality of diabetes care in OECD countries (Greenfield, et al., 2004). Their ultimate recommendation of the indicators to track was determined by: 1) whether the indicator captured an important performance aspect; 2) was scientifically sound and; 3) its tracking was potentially feasible. The importance of an indicator was further broken down into three dimensions: impact on health, policy importance and susceptibility to being influenced by the health care system. The scientific soundness of the indicator was based on both face and content validity. Finally, the feasibility was based on current data availability and potential reporting burden.

The review by Greenfeld and colleagues (2004) led to a recommendation of the following nine indicators:

- Processes of diabetic care
  - Annual HbA1c testing
  - Annual LDL cholesterol testing
  - Annual screening for nephropathy
  - Annual eye exam
- Proximal outcomes

    - HbA1c control
    - LDL cholesterol control
- Distal outcomes
    - Lower extremity amputation rates
    - Kidney disease in person with diabetes
    - Cardiovascular mortality in patients with diabetes

With respect to measuring blood pressure, Greenfeld et al. (2004) note that "measuring and reporting blood pressure control in a comparable fashion would be more challenging. The protocols for measuring and reporting of blood pressure would have to be standardized across countries and data collection would require dedicated reporting or Electronic Medical Records, whose implementation lags substantially the implementation of electronic laboratory systems."

In British Columbia, the Chronic Disease Management (CDM) program in the Ministry of Health has recommended tracking the following process measures for diabetes care (BCCDM, 2003):

- Two or more HbA1c tests during each fiscal year
- At least one eye exam during each fiscal year
- At least one microalbumin test during each fiscal year
- At least one lipid test every three years

The recommended clinical process procedures by the BCCDM program are identical to those of the OECD, with the exception of the frequency of testing. Rather than an annual HbA1c testing, the BCCDM recommends a minimum of two annual HbA1c tests. This concurs with recommendations by the American Diabetes Association (2005). The ADA recommends at least two HbA1c tests per year in patients who are meeting glycaemic treatment goals and four times per year in those who are not. On the other hand, the BCCDM recommends at least one lipid test every three years rather than an annual LDL cholesterol test.

In this study we will essentially follow the recommendations of the BCCDM in tracking adherence to recommended clinical procedures. In addition to these four procedures, a fifth

variable will be assessed as a proxy for blood pressure measurement, namely, whether or not the patient visited a general practitioner (GP) at least four times in a given fiscal year. The assumption behind this proxy measure is that the patient's blood pressure should be measured at every GP visit.

A key assumption in using process measures is that actions necessary to address, for example, poor blood pressure and glucose levels will be more likely when the practitioner-patient partnership adheres to the recommended type and frequency of clinical procedures than if the recommended clinical procedures are not performed. In other words, the assumption is that clinical vigilance and patient activity are synergistic, resulting in more favourable patient outcomes. In a recent editorial, Williams (2005) noted that "we don't know much about the relationship between the process of care and patient outcomes in the real world…most real world quality improvement efforts measure the process of care because it is easier than measuring outcomes. Therefore, most quality improvement efforts assume that a better process of care will lead to better patient outcomes." Is this actually the case?

Larsen et al. (1990) assessed whether routine measurements of HbA1c resulted in improved metabolic control in people with type 1 diabetes. Patients were randomly assigned to a study group who received HbA1c tests every three months and a control group who did not receive HbA1c tests. After a year, the mean HbA1c level fell significantly in the study group (from 10.1 to 9.5 percent) but not in the control group (from 10.0 to 10.1 percent). In addition, only 30% of individuals in the study group were in the poor control group (HbA1c levels above 10.0 percent) after a year compared to 50% in the control group. Finally, the study group were also hospitalized less often than the control group. Similar changes occurred in the control group when routine measurements of HbA1c were provided for this group the following year. The

researchers conclude that "regular measurements of haemoglobin A1c lead to changes in diabetes treatment and improvement of metabolic control, indicated by a lowering of haemoglobin A1c values."

Kahn et al. (1990) found that better processes of care were related to lower 30-day mortality for older patients hospitalized with congestive heart failure, myocardial infarction, pneumonia, and cerebrovascular accident. A number of researchers (Jencks et al., 1988; Park et al., 1990; Thomas et al., 1993) have studied the correlation between medical care and patient outcomes by assessing the validity of the annual hospital mortality statistics released in the United States by the Health Care Financing Administration (1987). The researchers concluded that single year mortality rates were not a good measure of the quality of care provided by the hospital. At best, they found a weak relationship between the two. Park et al. (1990), for example, noted that 56 to 82% of the excess mortality in hospitals with unexpectedly high mortality could result from purely random variation. More recent research on medical errors indicated that a portion of this excess mortality may be due to medical errors rather than simply random variation (Institute of Medicine, 1999; Stelfax et al., 2006).

A recent study by Higashi and colleagues (2005), however, found a much stronger relationship between performance as measured by process quality indicators and survival in vulnerable older adults living in the community. The researchers assessed the quality of care received by measuring a set of indicators covering 22 conditions. After adjusting for gender, health status and health service use, a higher quality of medical care was associated with lower mortality after 500 days. A key difference in this study compared to the three studies noted above is the longer follow-up period (three years vs. one year). One of the earlier research groups (Park et al., 1990) mentioned the one-year follow-up period as a significant limitation in its

work. This seems to be borne out by the fact that the correlation found by Higashi et al. only emerged after 500 days of follow-up. In commenting on the findings of Higashi and co-authors, Williams (2005) notes that the findings "are important because they provide evidence that quality improvement efforts that focus on the process of care improve patient outcomes." While such results need to be replicated, they do provide some support for the oft-assumed idea that improving the process of care leads to improved patient outcomes.

2.4 Adherence to Recommended Clinical Procedures

2.4.1 Compliance versus Adherence

Haynes et al. (1979) have defined *compliance* as "the extent to which a person's behaviour (in terms of medications, diets, or life-style changes) coincides with medical or health advice." They, as well as others (e.g., Kurtz, 1990; Johnson, 1992; Golin et al., 1996), suggested that the term *adherence* was interchangeable with compliance.

In contrast, Luftey and Wishner (1999) maintained that there are important ideological differences between the two terms. "The term *compliance* suggests a restricted medical-centred model of behaviour, while the alternative *adherence* implies that patients have more autonomy in defining and following their medical regimens." This distinction is particularly important when considering chronic diseases, such as diabetes, that involve complex care requirements. Compliance is a term which indicates that patients are largely responsible for their daily care requirements, while surrendering most of the decision-making to caregivers. Using *adherence* reflects a shift from an "authoritative practitioner-submissive patient model" (Luftey and Wishner, 1999) to one in which the patient carries an equal role in determining treatment protocol.

Anderson and colleagues (Glasgow and Anderson, 1999; Anderson and Funnell, 2000) suggest that the semantic shift recommended by Luftey and Wisher (1999) does not go far enough. They underscore that, in diabetes care, the patient is "fully responsible for the self-management of their illness. This responsibility is non-negotiable and inescapable" (Glasgow and Anderson, 1999, p. 2091). They suggest terms, such as 'self-care' and 'self-management,' that more appropriately represent "the cluster of daily activities that patients perform to manage their diabetes."

In response to these assertions from Anderson and colleagues, Luftey and Wishner (2000, p.1035) contend: "It is important to remember that even though patients are indeed responsible for their diabetes management, practitioners are also inescapably invested in these processes in ways that will not change with changes in terminology. They are responsible for prescribing regimens that patients can safely execute, and, moreover, for overseeing this self-management in a way that maximizes glucose control while protecting themselves and patients from liability and the negative consequences of uncontrolled diabetes."

In the following section we examine adherence to recommended clinical procedures, keeping in mind the role of both patients and physicians in co-managing diabetes. For the purposes of this discussion, adherence is defined as the degree to which actual practice coincides with recommendations as identified in diabetes CPGs.

2.4.2 Assessing Adherence to Recommended Clinical Procedures

People with diabetes who have a regular health care provider visit their provider more often and are more likely to receive recommended clinical procedures than those without a regular provider (O'Conner et al., 1998). A minimum of four annual visits to a primary care physician are required to receive the recommended clinical procedures noted earlier.

Harris (1990) estimated that people with diabetes in the United States visited their primary care physician an average of 2.7 times per year in 1985 for the ongoing care of their diabetes. In a further study based on a survey sample in 1989 in the United States, Harris (1996) found that approximately 10% of individuals with diabetes did not have a regular physician, 32% made fewer than four visits to their physician per year, 33% made four to six visits per year, and 26% made more than six visits per year. Also in the United States, Peters et al. (1996) found that patients with diabetes averaged 4.5 visits to their primary care physician in 1993, but 21% had one or fewer visits. Further, Hiss (1996) found that patients who are taking insulin tended to visit their primary care physician more often (i.e., 4.6 visits) compared to those who are not taking insulin (i.e., 3.2 visits).

In Canada, Watson et al. (2003) established that residents of Winnipeg, Manitoba who had diabetes tended to see a family practitioner an average of just over seven times in a year. This rate did not change appreciably between 1992 and 2001. In Ontario, researchers found that the average number of visits to a family physician was somewhat higher, at just under ten per year (Chan and Harju, 2003). In the Vancouver area of British Columbia, younger adults with diabetes visited their general practitioner an average of 5.6 times per year in 2000/01. Adults over 65 visited their general practitioner 8.7 times per year (Broemeling et al., 2004).

The literature indicated that a substantial proportion of people with diagnosed diabetes were not receiving the recommended clinical procedures. Rubin and co-workers (1998) noted that only 34% of people with diabetes in their study population had at least one HbA1c test per year, only 23% had an annual eye exam, and only 39% received a yearly cholesterol screening. McGlynn et al. (2003) found that only 24% of adults with diabetes had received three or more glycosylated haemoglobin tests over a two-year period, and a bare 14% had an annual eye exam.

They noted that 58% had their total serum cholesterol and HDL cholesterol tests documented. Overall, the study by McGlynn and colleagues revealed that people with diabetes received just 45% of the processes recommended for basic care of their chronic condition. The United States Agency for Healthcare Research and Quality published a report (i.e., *National Healthcare Quality Report*, 2003) which noted that 55% of adults with diabetes reported receiving an influenza vaccination in the previous year, 66% reported having a foot exam, 67% reported having a retinal eye exam, 90% reported having an HbA1c measurement at least once in the past year, and 94% reported receiving a lipid profile in the past two years. Only 21% of patients, however, reported having all five major tests done in the past two years.

In Winnipeg, Manitoba, Katz et al. (2004) found that 54% of patients with diabetes had a cholesterol screening test and 37% had an eye exam during a one year period. In Ontario, Harris et al. (2003) found that 84% of their random sample of patients with diabetes had at least one HbA1c test ordered in the previous year, 28% were tested for microalbuminuria, 15% were examined for diabetes-related foot problems, 88% had their blood pressure measured, and 48% had their lipid profiles documented in their chart.

The British Columbia Chronic Disease Management (BCCDM, 2003) department of the BC Ministry of Health Services accessed administrative data to determine whether patients throughout the province were receiving the series of services recommended in current clinical practice guidelines. In the fiscal year 2002/03, only 39% of people with diagnosed diabetes in the province had two or more HbA1c tests. A higher number (i.e., 43%) had an eye exam, but only 34% had a microalbumin test. The most encouraging finding was that 78% had at least one lipid test in the three years from 2000/01 to 2002/03 (BCCDM, 2003).

Comparing the results of these different studies is problematic in that the definitions of the study populations differed. Furthermore, the results were derived variously from self-report, chart abstracts or administrative data. Some studies used a one year window while others used a two year window. Finally, the diagnostic tests were not identical across settings. Nevertheless, it was apparent that a large portion of patients with diagnosed diabetes were not receiving the recommended clinical procedures.

Some studies have uncovered patient characteristics that are associated with variability in adherence. For instance, place of residence appeared to make a difference. Jencks and coauthors (2000), for example, found that adherence varied significantly by US state for annual HbA1c testing, biennial eye exams and biennial lipid profiles. The median rate for HbA1c testing was 71% with a range from 52 to 85%. Similarly, it was 69% for eye exams (with a range from 56 to 80%) and 57% lipid profiles (with a range from 39 to 73%).

In a follow-up study, Arday et al. (2002) adjusted for patient characteristics such as age, gender, race and socio-economic status. These adjustments reduced the variance between US states in HbA1c tests, eye examinations and lipid profiles by 30, 23 and 27%. The authors noted that "while the variation explained by person-level characteristics (one-fourth to one-third of the variance among states) is considerable, a majority of the variation among states remains unexplained." This study also highlighted the potential relationship between patient characteristics and varying levels of adherence. Lower rates of adherence for the three diagnostic tests was observed in patients under the age of 65, blacks, those living in a community with a lower socio-economic status and those with five or fewer outpatient physician visits during the two year study period.

Woodward et al. (2006) assessed the frequency and outcomes of HbA1c tests over a period of one year among eastern Ontario patients with diabetes. Only 58% of the study population had at least one HbA1c test during the study year. They found that older individuals were more likely to be tested than younger individuals. In addition, males were more likely to be tested than females and those individuals who visited a physician (i.e., GP or specialist) more often were also more likely to be tested.

The literature revealed that while overall results suggest suboptimal adherence, there has been some improvement in adherence over time, at least in certain jurisdictions. Using a retrospective chart review, Stolar et al. (1995) gauged the impact of the ADA's 1988 clinical practice guidelines for patients with type 2 diabetes. They assessed adherence to recommended clinical procedures for the three years before and after the 1988 guidelines were published. They found significant improvements in a number of areas. Selected results are summarized on table 2-4.

Table 2-4: Percent of Patients Receiving Recommended Clinical Procedures

	Initial Visit	Midpoint Visit	Final Visit
Eye exam	46.3%	57.3%*	67.8%*
HbA1c	59.1%	73.9%*	82.2%*
Cholesterol	60.5%	67.0%*	76.7%*
High-density lipoproteins	17.0%	30.3%*	50.6%*
Low-density lipoproteins	15.2%	27.7%*	48.9%*
Triglycerides	43.9%	50.2%*	67.0%*
Urinalysis	67.7%	64.0%	67.1%
24-hr creatinine clearance	7.0%	9.4%	14.9%*

Based on Stolar et al. (1995)
** significant change from previous visit*

Jencks et al. (2003) assessed changes in the proportion of Medicare beneficiaries with diabetes who received at least one HbA1c test per year, at least one eye exam every two years

and at least one lipid profile every two years. Between 1998/99 and 2000/01, these proportions increased from 70% to 78%, 69% to 70% and 58% to 74% respectively.

In England, Campbell and colleagues (2005) used medical records data to assess changes in the receipt of recommended care between 1998 and 2003. They found a significant improvement in the quality of care provided to individuals with type 2 diabetes during that time. More specifically, the proportion of individuals who had at least one HbA1c tests during the previous 15 months increased from 87.6% to 92.7%. Similar increases were observed for the measurement of serum creatinine levels (from 79.8% to 89.5%) and serum cholesterol levels (from 74.9% to 97.6%). Increases for eye exams (from 70.8% to 71.8%) and blood pressure (from 92.8% to 94.6%) were more modest. Beerstecher (2005) has cautioned, however, that these results might not reflect an increase in the quality of the care provided but simply an improvement in data recording.

The move toward better care has been evident in British Columbia. In this province, the proportion of people with diagnosed diabetes who received two or more HbA1c tests per year increased from 31% in 1999/00 to 39% in 2002/03. Similarly, the proportion with at least one microalbumin test per year increased from 22% to 34%. The proportion with at least one lipid tests in three years increased from 61% to 78%. Unfortunately, the proportion of people with at least one eye exam per year decreased from 47% to 43% (BCCDM, 2004).

The problem of sub-optimal adherence to recommended clinical procedures is not isolated to patients with diabetes. A study by McGlynn et al. (2003) found that patients with a wide variety of chronic conditions received just 56% of care as recommended in CPGs. Nor is it isolated to specific countries. A study by Schoen et al. (2005) compared the receipt of recommended services for adult patients with diabetes in six countries (Australia, Canada, New

Zealand, United Kingdom, United States and Germany). They discovered that the countries all fell into a range from 38 to 58%, for evidence that patients had received all of the following services: an HbA1c test in the last six months; a foot or eye exam in the past year; and, a cholesterol check in the past year.

2.4.3 Why is Adherence Generally Sub-Optimal?

2.4.3.1 Physician Factors

Early research on the reasons for poor adherence to clinical practice guidelines tended to focus on the physician. Cabana et al. (1999) identified three broad potential physician-based barriers to CPG adherence:

- Physician knowledge (lack of awareness or lack of familiarity with CPG).
- Physician attitudes (lack of agreement, lack of self-efficacy, lack of outcome expectancy, or the basic inertia of previous practice).
- Physician behaviour (including external barriers).

Weinberger et al. (1984) assessed whether physicians who were more successful at controlling their diabetic patient's blood glucose levels could be distinguished from less successful physicians: was their success in managing diabetic patients tied to their knowledge? Was it tied to their attitudes? The researchers found that differing levels of knowledge alone did not distinguish between the two groups. It was intentions and beliefs that distinguished the two groups.

Other research points to knowledge as a factor. While CPGs are usually widely disseminated, Wolff et al. (1998) found that only 27% of family physicians in the US knew where to find a CPG. Furthermore, approximately one-third of physicians were unfamiliar with the content of specific guidelines (Ward et al., 2002; Wolfe et al., 2004). Targeting individual

physicians for education (i.e., *academic detailing*) has been shown to be successful (Goldberg et al., 1998), but is very labour-intensive and expensive (Greco and Eisenberg, 1993).

Many researchers have focused on physician attitudes toward CPGs and the relationship between those attitudes and behaviour (Anderson et al., 1991; Halm et al., 1999). The majority of physicians tend to agree that CPGs are good educational tools and convenient sources of advice, and that they are developed to improve the quality of health care (Lomas et al., 1989; Tunis et al., 1994; Weingarten et al., 1995; Siriwardena, 1995; Gupta et al., 1997; Hayward et al., 1997; James et al., 1997; Wolff et al., 1998; Farquhar et al., 2002). This generally positive attitude toward CPGs, however, was not found in all studies. Interestingly, approximately one quarter of physicians view CPGs negatively, describing them as oversimplified or "*cookbook*" medicine, too rigid to apply to individual patients and a challenge to physician autonomy (Tunis et al., 1994; Weingarten et al., 1995; Siriwardena, 1995; Hayward et al., 1997; James et al., 1997; Wolff et al., 1998; Costantini et al., 1999; Chasuk et al., 2001; Farquhar et al., 2002; Boyd et al., 2005).

When researchers examined the implementation of CPGs, they discovered that few physicians reported making changes to their clinical practice based on published guidelines (Tunis et al., 1994; Hayward et al., 1997; James et al., 1997; Wolff et al., 1998). Indeed, CPGs ranked well below other sources of information, including continuing medical education, discussions with colleagues, and review articles, in influencing physician practice patterns (Tunis et al., 1994; Gupta et al., 1997; Hayward et al., 1997). Weingarten et al. (1995) found no significant association between physicians' attitudes toward CPGs and the implementation of guidelines.

The Canadian study by Hayward et al. (1997) noted that overall, "it seems that the challenge is not so much to overcome negative attitudes about guidelines but more to develop strategies that will influence physicians to read, remember and use them." Two key conclusions from their study were: 1) for physicians to adopt guidelines, they may require an authoritative endorsement; and 2) CPGs should be presented to doctors in a format that promotes their use, such as short pamphlets, official manuals summarizing a number of guidelines, journal articles summarizing new guidelines, and pocket cards.

The concern about endorsement was reflected in the results of other studies, where key factors influencing the uptake of CPGs by physicians included whether the guidelines had been endorsed by appropriate professional organizations and / or physician opinion leaders, as well as whether the guidelines were based on evidence such as systematic reviews (Lomas et al., 1991; Gupta et al., 1997; James et al., 1997; Hayward et al., 1997).

Finally, another potential reason for poor adherence to CPGs for diabetes is that office-based management of diabetes has simply increased in complexity during the 1990s (Grant et al., 2004).

2.4.3.2 Patient Factors

While the initial research into reasons behind poor adherence to CPGs focused on the physician more recent research has focussed on the role of the patient and the physician-patient relationship. The literature on adherence to diabetes treatments suggests that patients follow regimens more readily given the following conditions: 1) if the treatments involve medications rather than lifestyle changes (Anderson et al., 1993; Glasgow et al., 1987); 2) if the perceived severity of the disease is high (Kurtz, 1990) and there is a recognized direct connection between symptoms and disease (Peyrot et al., 1987); 3) if medications alleviate uncomfortable symptoms

and minimize the risk of hypoglycaemia (Kurtz, 1990; Peyrot et al., 1987); 4) if they believe the recommended treatment will enable them to delay or avoid complications (Peyrot et al., 1987; Bobrow et al., 1987); and, 5) if the regimen is simple rather than complex (Ary et al., 1986).

Anderson et al. (1993) divided diabetic patients into low and high adherence groups. The largest differences were in the more difficult adherence areas (i.e., in following recommendations for diet and exercise). Larme and Pugh (1998) studied the attitudes of primary care providers towards diabetes using qualitative research methods. Among their results is the conclusion that diabetes is harder for providers to treat than other chronic conditions because its successful management relies to a great extent on lifestyle change which is largely outside of provider control; further, treatment is complex and requires close coordination between patients and physicians.

In a US study, James et al. (1998) found that patient-specific factors were associated with a physician's decision to adhere to guideline recommendations. For instance, physicians were more lax with patients that had difficulties in affording health care, a reduced quality of life because of a co-morbidity, or a desire to stay in their community with family even when that meant limited access to specialty services. The authors assessed whether a "physician's attention to providing quality interpersonal care may conflict with providing quality technical care". Their conclusion expands on this phenomenon: "This study suggests that medical decisions in primary care are affected by patient preferences distinct from biomedical aspects of disease. This insight, although not new to family physicians, is extremely important for those who would measure health care quality through measures of physician adherence to disease-specific guidelines".

Wagner (2001) notes that many chronically ill people have socioeconomic factors, disabilities, and co-morbid conditions that make it harder for practitioners and practice systems

to help them. In particular, the co-occurrence of mental disorders and other chronic diseases negatively impacts on the interaction between the care provider and the patient (Simon, 2001; Osborn, 2001; Piette et al., 2004; Selby et al., 2004; Frayne et al., 2005).

A number of studies have assessed the relationship between the patient's race or ethnicity and physician or patient adherence to prevention guidelines (e.g. Martin et al., 1995; Harris, 2001; Heisler et al., 2003; Mainous et al., 2004). In a recent review of this literature, Lanting et al. (2005) found that diabetic patients from minority groups had higher mortality rates and were at a higher risk of the complications associated with diabetes. After adjusting for risk factors such as smoking, socioeconomic status, income, years of education, and body mass index, however, ethnic differences tended to disappear. Ethnic differences in process of care (e.g. the receipt of recommended services such as HbA1c tests, blood pressure testing, etc.) were observed only in blacks (compared to whites) in the United States. While blacks in the United States had an increased risk of mortality and diabetes complications compared to whites, the opposite association was found in the United Kingdom. This suggests that differences observed in the United States were probably not due to genetics but most likely due to differences in the health care systems in the two countries (i.e., universal access in the UK).

Indeed, differences in the organization of health care services have been posited as a major factor in the level of adherence to CPGs. It is to these organizational factors that we now turn our attention.

2.4.3.3 Organizational Factors

Recent research has begun to examine organizational factors beyond the individual provider or patient in assessing the adherence to CPGs (The TRIAD Study Group, 2002). For

instance, Curry (2000) has noted that benefit and reimbursement policies have an impact as do investments in clinical information systems.

A systematic review of studies comparing community-based and hospital-based care for people with diabetes found that the community setting was as good as or better than the hospital, provided that the community-based system included a computerized central recall to prompt both providers and their patients. Otherwise, unstructured care in the community was associated with poorer follow-up, greater mortality and worse glycaemia control than hospital-based care (Griffen and Kinmouth, 2004).

A number of studies (Harrold et al., 1999; Donohoe, 1998) have suggested that specialists are more knowledgeable about the management of conditions associated with their specialty, and that they are more likely to adhere to CPGs. Rothman and Wagner (2003), however, underscore that it is the design of the health care system, rather than the specialty of the physician, that is the primary determinant of chronic care quality. This is an issue that we will return to in the next section.

A number of other studies (Renders et al., 2001; Renders et al., 2004; Shiffman et al., 2004) also identify systematic arrangements for patient follow-up as important in improving process outcomes in diabetic care. Literature reviews by Renders et al. (2001, 2004) also revealed that the effective use of nurses in the care process and enhanced patient education were important success factors.

Others (Michie and Johnston, 2004) noted the importance of clear, concise behavioural recommendations, and suggested that rewriting guidelines to increase behavioural specificity may be the simplest, most effective method of increasing their implementation.

In summary, the literature identified a variety of physician, patient and organizational challenges which interfered with adherence to recommended clinical procedures. The most important recommendations for improvement were organizational, including appropriate financial incentives, a computerized central recall system, the involvement of nurses in the care process, and enhanced patient education.

2.4.4 Factors that Promote Adherence

In addition to the challenges that need to be addressed, research has also revealed positive factors that promote adherence. National guidelines for family practice have been developed and disseminated in a rigorous, structured manner since 1987 in the Netherlands (Grol et al., 1995). The result among family practitioners has been an average adherence rate of 67% (Grol, 2001). Key factors predicting adherence include recommendations that define the desired performance very concretely, that are compatible with existing values, and that do not have major consequences for the organization of health care. Lessons learned from what is described, in the opinion of the authors, as the "most comprehensive programs for evidence-based guideline development and implementation in the world" (Grol, 2001, p. II-52) include:

- Rigorous development of clinical guidelines at a national level is both feasible and well-accepted by the target group when it is 'owned and operated' by the profession itself.
- A comprehensive strategy to disseminate the guidelines via various channels, both written and personal, appears to be very important.
- A program to implement a guideline should be well-designed, well-prepared, and preferably pilot-tested before use.

A systematic review by Grimshaw et al. (2001) of interventions designed to change provider behaviour noted that multifaceted interventions targeting different barriers to care were likely to be more effective than single interventions. The most successful programs addressed: 1) clinician behaviour; 2) changes to the organization of practice; 3) information system

enhancement; 4) and educational or supportive programs aimed at patients (Renders et al., 2001; Rothman and Wagner, 2003). Renders et al. (2004) noted that key aspects of successful CPG implementation in the care of diabetic patients included: 1) organizational interventions that improved regular prompted recall and review of patients; 2) a stress on patient-oriented interventions; and, 3) the utilization of nurses in patient education and the facilitation of adherence to treatment.

Wagner and colleagues in Seattle have developed a chronic care model which includes: 1) key linkages with community resources; 2) active leadership support; 3) more consistent and collaborative self-management support; 4) system redesign to include non-physician personnel in practice teams; 5) clinical information system enhancements to include reminders and feedback on the care provided; and, 6) attention to co-morbid conditions (Wagner et al., 1996; Wagner et al., 2001; Bodenheimer et al., 2002a, 2002b, 2002c; Heisler and Wagner, 2004).

An important aspect of the chronic care model is the concept of patient self-management. "Patients with chronic conditions make day-to-day decisions about – self-manage – their illnesses. This reality introduces a new chronic disease paradigm: the patient-professional partnership, involving collaborative care and self-management education" (Bodenheimer et al., 2002c). Bodenheimer et al. (2002c) provide the following comparison of traditional and collaborative care in chronic illness.

Table 2-5 Comparison of Traditional and Collaborative Care in Chronic Illness		
Issue	**Traditional Care**	**Collaborative Care**
What is the relationship between patient and health professional?	Professionals are the experts who tell patients what to do. Patients are passive.	Shared expertise with active patients. Professionals are experts about the disease and patients are experts about their lives.
Who is the principal caregiver and problem solver? Who is responsible for outcomes?	The professional.	The patient and professional are the principal caregivers; they share responsibility for solving problems and for outcomes.
What is the goal?	Compliance with instructions. Non-compliance is a personal deficit of the patient.	The patient sets goals and the professional helps the patient make informed choices. Lack of goal achievement is a problem to be solved by modifying strategies.
How is behaviour changed?	External motivation.	Internal motivation. Patients gain understanding and confidence to accomplish new behaviours.
How are problems identified?	By the professional, e.g. changing unhealthy behaviours.	By the patient, e.g., pain or inability to function; and by the professional.
How are problems solved?	Professional solve problems for patients.	Professionals teach problem-solving skills and help patients in solving problems.

Early results, in terms of both adherence and outcomes, from the implementation of this chronic care model in a variety of settings are very positive (Bodenheimer et al., 2002), though more formal evaluations need to carried out, including assessment of longer term patient outcomes (Narayan et al., 2004).

A review of 177 Veteran's Affairs clinics in the United States found that programs "associated with better diabetes control simultaneously have teams that actively involve physicians in quality improvement, use electronic health information systems, have authority to respond to staffing and programmatic issues, and engage patients in care." (Jackson et al., 2005, p. 225)

Financial incentives for improvements in the quality of care have been applied in the United Kingdom (McElduff et al., 2004; Roland, 2004), Australia (Practice Incentives Program, 2001) and British Columbia (Full Service Family Practice Incentive Program, 2003). The most extensive application of this model is found in the UK, where an estimated 30-50% of a general practitioner's income may be dependent on meeting specific quality targets. This approach is still in its infancy and has not yet been fully evaluated. Early research (Dudley, 2005; Rosenthal, et al., 2005), however, has suggested that "paying clinicians to reach a common, fixed performance target may produce little gain in quality for the money spent and will largely reward those with higher performance at baseline" (p. 1788).

In conclusion, while adherence to recommended clinical procedures for diabetes is generally poor, a number of organizational factors which can improve adherence have been identified in the literature. These include:

- active leadership support
- guidelines that are *owned and operated* by the profession
- enhanced patient education and self-management support
- the inclusion of non-physician personnel in practice teams
- information systems designed to provide timely reminders and feedback
- attention to co-morbid conditions
- comprehensive dissemination strategy

2.5 Improving Adherence to Recommended Clinical Procedures

In this section we survey a number of specific programs that have been successful in improving adherence.

Rubin and co-authors (1998) reviewed the Diabetic Care of America's (DCA) Diabetes NetCare[SM] program. Within a year of this program's implementation, 76% of patients received at least one HbA1c test per year (compared with 34% prior to the program). Furthermore the percentage of patients receiving an annual eye exam rose from 23% to 40%, those receiving an annual foot exam rose from 2% to 25%, and those receiving an annual cholesterol screening rose from 39% to 63%. The average HbA1c level dropped from 8.9% to 8.5%.

Sperl-Hillen et al. (2000) assessed patients 12 months after the implementation of a comprehensive diabetes management program in which the specific goals were to improve glycemic control and reduce cardiovascular risk in all adult diabetes patients. They found a significant improvement in mean HbA1c levels, including an increased proportion of patients with an HbA1c level below 8%, as well as a significant increase in the fraction of patients with acceptable lipid control.

Berg and Wadhwa (2002) assessed patients six months after enrolment to the McKesson Health Solutions Diabetes CareEnhance program. The number of patients having an HbA1c test increased from 56.1% at program intake to 81.3% at 6 months. There was a decrease in symptoms of hyperglycaemia (i.e., during the past two weeks) from 28% at intake to 13.1% at six months. They also found a significant reduction in hospitalizations from a pre-enrolment annualized utilization rate of 1,110 per 1,000 population to 847 per 1,000 population.

Bodenheimer et al. (2002a) cite a number of unpublished results from groups that have implemented a variation of the chronic care model developed by Wagner and colleagues. In a

program in Ohio, the proportion of patients with HbA1c levels below 7% had increased from 42% to 70% after the implementation of the chronic care model. In Minneapolis, the proportion of diabetic patients with an HbA1c level of less than 8% increased from 60.5% to 68.3%. In Colorado, the average HbA1c level dropped from 10.5% to 8.6% between October of 1998 and March of 2000. The number of patients receiving at least two HbA1c tests within a year increased from 11% to 71% during that time period.

A recent study (Dorr et al., 2005) evaluated the impact of implementing the chronic care model at Intermountain Health Care in Salt Lake City. Key elements of the model included care managers who were placed in clinics with the role of facilitating team collaboration and patient education as well as leveraging existing information technology to allow the primary care teams to adopt numerous different care guidelines at once. Using this approach, they found that the odds of being overdue for HbA1c testing decreased by 21%. For those people who were overdue the odds of being tested increased by 49%. Similarly, the odds of having an HbA1c level < 7.0 percent increased by 19%.

Beginning in 1995, the Department of Veterans Affairs (VA) in the US embarked on a nation-wide effort to reengineer its services with a view towards improving both efficiency and effectiveness of delivery. Kerr et al. (2004) compared the outpatient care received by patients with diabetes in the VA system to that found in commercial managed-care systems. The results showed that patients in the VA system were more likely to receive HbA1c testing, counselling about aspirin use, and eye and foot examinations. They also had better lipid control.

Sperl-Hillen and O'Conner (2005) reported on 10 year trends in glycemic and lipid control in adults with type 2 diabetes enrolled in the HealthPartners Medical Group (HPMG) in Minnesota. The HPMG identified diabetes as a priority area in 1995 and implemented a

multifaceted improvement program. Between 1994 and 2003, median A1c levels in the patient population decreased from 8.3 to 6.9. During the same time period, mean LDL (mg/dL) decreased from 132 to 97. Among Sperl-Hillen and O'Conner's conclusions were the following:

- Primary care clinics can successfully improve diabetes care in the absence of carve-out disease management. Primary care physician continuity of care is significantly related to better diabetes care.
- The final common pathway to A1c and LDL improvement is intensification of pharmacotherapy.
- Certain groups of patients have had less improvement in A1c and LDL than other groups. Those with the most difficulty included younger adults and those with a current or former diagnosis of depression
- Financial accountability and performance incentives for diabetes performance may facilitate improvement.

In a systematic review of diabetes disease management programs, Knight et al. (2005) note that disease management programs on average have a modest but clinically and statistically significant effect on glycaemic control (0.5 percentage point reduction). This compares to a two percentage point reduction in patients with type 1 diabetes in the DCCT and a 0.9 percentage point reduction in patients with type 2 diabetes in the UKPDS. As noted earlier, both of these studies involved very intensive interventions that would be hard to maintain in *real world* situations.

These examples indicate that a concerted effort to improve adherence can indeed improve the care that diabetic patients receive, often within a very short time period after program implementation.

2.6 Potential for Savings Associated with Improved Adherence

As noted earlier, there is a substantial amount of evidence indicating that the appropriate control of blood glucose and blood pressure results in the avoidance or minimization of the serious complications associated with diabetes. To a lesser extent, there is also evidence that an improvement of process measures (i.e., getting the recommended tests) is associated with improved outcomes. As the examples in the previous section demonstrated, implementation of a comprehensive management program can result in significant and sometimes rapid improvement in adherence to recommended clinical procedures. What is less clear is whether these improvements resulted in lower health care costs either immediately or over the long term.

Initial work assessing the outcomes and costs associated with the implementation of comprehensive planned management programs for people with diabetes tended to be based on extrapolation from cost-effectiveness models. With the publication of longitudinal results from the DCCT and the UKPDS, actual results concerning long-term complication rates became available for use in cost-effectiveness studies. The early models assumed, and the results of the DCCT and UKPDS confirmed, that cost savings *would* result from a reduction in downstream complications, but that these savings would take from 5 to 10 years to become apparent. Funding agencies, however, are not always willing to wait for long-term results. To address the short-term economic imperative, a number of more recent studies have begun to assess the short-term financial impact of improving blood pressure and glycaemic control (Killilea, 2002; White, 2002; Clouse et al., 2002; Zhang et al., 2004).

Siegel et al. (1992) modelled the impact of screening for microalbuminuria or proteinuria followed by early treatment with angiotensin-converting enzyme inhibitors. They suggested that

screening for microalbuminuria would cost from $7,000 to $16,500 per year of life saved, while screening to detect proteinuria would actually be cost saving.

Javitt et al. (1991) demonstrated that the timely detection and treatment of retinopathy in patients with type 1 diabetes should result in considerable savings to the US federal government while at the same time increasing person-years of sight. Further work by Javitt et al. (1994) showed similar results for patients with type 2 diabetes. Based on computer modelling, they estimated that screening and treatment for eye disease in patients with type 2 diabetes would generate annual savings of $247.9 million to the federal budget. In addition, 53,986 person-years of sight would be saved annually. This estimate was based on a participation rate of 60%. With a 100% participation rate, these estimates increased to an annual savings of $472.1 million and 94,304 person-years of sight.

In a follow-up study, Javitt and Aiello (1996) approached the timely detection and treatment of retinopathy from a societal perspective and estimated that the cost per quality adjusted life year (QALY) saved was $3,190. This was broken down into $1,996 for those with type 1 diabetes, $2,933 for those with type 2 diabetes who used insulin for glycaemic control, and $3,530 for those with type 2 diabetes who did not use insulin.

Gilmer et al. (1997) modelled the relationship between baseline HbA1c levels in type 2 diabetic patients and health care costs over the following three years. For every 1% increase in HbA1c, their model found a statistically significant increase in health care costs over three years, ranging from $400 to $4,000 per patient. It is likely therefore that decreases in HbA1c levels would result in cost savings.

Eastman et al. (1997) developed a model comparing standard treatment (i.e., $890 per patient per year) with comprehensive treatment (i.e., $2,873 per person per year). Their model

predicted that comprehensive treatment maintaining HbA1c levels at 7.2% would reduce the cumulative incidence of blindness, end-stage renal disease and lower-extremity amputation by 72%, 87% and 67%, respectively, at a cost of $16,000 per quality adjusted life year saved.

With the completion of the DCCT in the United States, actual long-term results were available for the first time to assess the cost-effectiveness of intensive versus conventional control of blood glucose levels in patients with type 1 diabetes. The study by the Diabetes Control & Complications Group (1996) estimated that implementing intensive rather than conventional therapy for every person with type 1 diabetes in the United States in 1994 would cost $4.0 billion over the lifetime of that population, or $28,661 per year of life saved. In addition, intensive therapy would produce the following results per patient compared to conventional approaches:

- 7.7 years of additional sight,
- 5.8 additional years free from ESRD,
- 5.6 additional years free from lower extremity amputation,
- 15.3 additional years free from any significant microvascular or neurologic complications.

A major criticism of the DCCT study is that participants were highly motivated and thus the results may not be transferable to general practice settings (Rubin et al., 1998). Furthermore, the additional medical resources used in the intensively treated population of $4,000 to $5,800 per participant (DCCT, 1995) would make the protocol prohibitively expensive to replicate in general practice settings.

In the UKPDS (1998b), the cost of treatment for patients in the *tight* control of blood pressure group increased by 21%, primarily due to a doubling of the cost of antihypertensive

drugs compared to the *less tight* control of blood pressure group. This increase, however, was more than offset by the 17% reduction in the cost of complications. The overall undiscounted cost of treatment and complications was 2.3% less for the *tight* control of blood pressure group. The authors conclude that "tight control of blood pressure in hypertensive patients with type 2 diabetes substantially reduced the cost of complications, increased the interval without complications and survival, and had a cost effectiveness ratio that compares favourably with many accepted healthcare programmes."

Similar conclusions were drawn by Gray et al. (2000) for intensive blood glucose control in patients with type 2 diabetes. Intensive glucose control increased costs by £695 per patient but reduced the cost of complications by £957 compared with conventional management. Most of the savings were due to a reduction in hospital-based costs in the intensive blood glucose control group.

Rubin et al. (1998) studied the short term experience with of a group of 7,000 people with diabetes enrolled in the Diabetic Care of America's (DCTA) Diabetes NetCare^{SM} program. They found that the initiation of a comprehensive diabetes management program resulted in overall savings to the health care system of 12.3% within the first year. These savings were primarily related to a reduction in both acute care admissions (by 18%) and in the length of stay once admitted. This study also noted a 1.8% decrease in overall pharmacy costs (i.e., after adjusting for general drug price increases), but an increase in physician costs of 2.1%, associated with the implementation of a comprehensive diabetes management program. The actual costs of implementing the program remained proprietary, but the authors did state that there would be a breakeven point at 1,265 diabetic patients.

Testa and Simonson (1998) studied the very short-term effect (i.e., within 15 weeks) of active hypoglycaemic therapy versus placebo in a randomized controlled trial. They examined symptoms, quality of life, work productivity and health care use. Patients receiving active hypoglycaemic therapy reported better health and work productivity and less use of ambulatory care.

Wagner et al. (2001) compared the health care costs of two diabetic cohorts over a five year period (1992 – 1997). They examined a group in whom glycaemic control improved and a group in whom glycaemic control did not improve. Differences in the number of primary care visits reached statistical significance within two years. Differences in total costs reached statistical significance within three years. Mean total health care costs were between $685 and $950 less per year for patients in whom glycaemic control improved. Thus this study provided a robust example of short-term cost savings.

Menzin et al. (2001) also investigated the short-term economic benefits of improved glycaemic control. Using a retrospective chart review design, they assigned patients with diabetes to three groups based on HbA1c levels: good control (<8%), fair control (8% - 10%) and poor control (>10%). They assessed differences in inpatient admissions for short-term complications, including hyperglycaemia, hypoglycaemia, selected infections, and electrolyte imbalance. Over a three year period, the adjusted rate of inpatient treatment ranged from 13 admissions per 100 patients for the good control group, to 16 per 100 for the fair control group, to 31 per 100 for the poor control group. Average costs per diabetic patient in the three groups were $970, $1,380 and $3,040, respectively. Among patients with chronic diabetic complications, the difference in results between the good and poor glycaemic control scenarios were even more marked.

Berg and Wadhwa (2002) assessed patients six months after enrolment to the McKesson Health Solutions Diabetes CareEnhance program. The number of patients having an HbA1c test increased by 44.9%. Six months after enrolment, patients showed a 53.2% decrease in symptoms of hyperglycaemia. The researchers also found a significant reduction in inpatient admissions, resulting in a calculated return on investment of more than four to one (i.e., 4.34:1).

Villagra and Ahmed (2004) studied the short-term outcomes associated with the implementation of diabetes disease management programs (DDMPs) in ten US States, involving over 43,000 individuals with diabetes. Within a year after the implementation of the DDMPs, significant improvements were observed in the provision of dilated retinal exams, microalbumin testing, lipid testing and tobacco use. A positive trend was observed for HbA1c testing and prescriptions for angiotensin-converting enzyme inhibitors or angiotensin receptor blockers. Overall costs decreased by 8.1%, driven largely by a 22-30% reduction in hospitalization costs. However, pharmacy costs were higher with the DDMPs in place.

Not all studies of disease management programs have found cost savings. Fireman et al. (2004) reviewed the Kaiser Permanente experience in Northern California with disease management programs in diabetes, asthma, heart failure and coronary artery disease between 1996 and 2002. They found evidence of substantial improvements in the quality of care associated with the implementation of disease management programs, but not cost savings. Crosson and Madvig (2004) explained that this study used a very restrictive definition of cost savings and that it was carried out in a mature delivery system known for its efficiency. They refuted the criticism of Fireman and colleagues, asserting that much of the "low-hanging fruit, in terms of cost management" may have been harvested prior to the implementation of their disease management programs.

In summary, the majority of studies assessing the planned management of care for people with diabetes show, in the immediate and longer term, an improved adherence to recommended clinical procedures, the avoidance or minimization of the serious complications associated with diabetes and a reduction in costs.

2.7 Summary

Diabetes is a common and serious chronic condition. If it is not well-managed, significant multi-system complications often arise resulting in an increase in health care utilization. There is considerable evidence which indicates that people with diagnosed diabetes are not receiving the recommended care. A comprehensive program aimed at improving adherence to recommended care can improve the treatment that these patients receive, often within a very short time period. Furthermore, the implementation of a diabetes disease management program results in better patient outcomes which translated into reductions in health care utilization and concomitant cost-savings.

The primary objective of this study was to determine whether adults with diagnosed type 2 diabetes who have a higher adherence to recommended clinical procedures utilized a higher volume of physician services and a reduced volume of acute care services over a given five year period. A further objective was to assess whether adherence for this study population changed over time. For this analysis, routinely collected administrative data for the five year period from April 1, 1996 to March 31, 2001 was accessed. The population selected for analysis consisted of patients with diagnosed type 2 diabetes living within the geographic boundary of the Fraser Health Authority, a large region in south western British Columbia with a population of 1.4 million.

More specifically, the questions addressed will be:

1. Has the level of adherence to recommended clinical procedures by adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority in British Columbia changed during the five years from April 1, 1996, to March 31, 2001?
2. Which patient characteristics (e.g. age, gender, socio-economic status, general level of morbidity, disease-specific severity level and geographic area of residence) are associated with improved long-term adherence to recommended clinical procedures?
3. What is the relationship between improved long-term adherence and the average annual utilization of physician, acute care and total costs?

A number of studies have assessed various aspects of the relationship between adherence and patient characteristics. These studies tend to assess adherence based on a single snapshot of the receipt of recommended services over a one or two year period. In the current study we will develop an adherence measure based on a clinical protocol that spans a five year time period. To our knowledge, this is the first study to assess the relationship between patient characteristics and long-term adherence to recommended clinical procedures.

The individual patient's adherence level will be included as an additional patient characteristic. We will then assess the relationship between patient characteristics and the utilization of physician, acute care and total health care costs, paying special attention to the role of the patient's adherence level in this relationship. A number of studies have assessed the impact of the overall improvement of adherence on health care costs. To our knowledge, this is the first study to investigate the relationship between long-term adherence to recommended

clinical procedures, patient characteristics and of health care costs in patients with diagnosed type 2 diabetes.

CHAPTER III: METHODS

3.1 Conceptual Framework

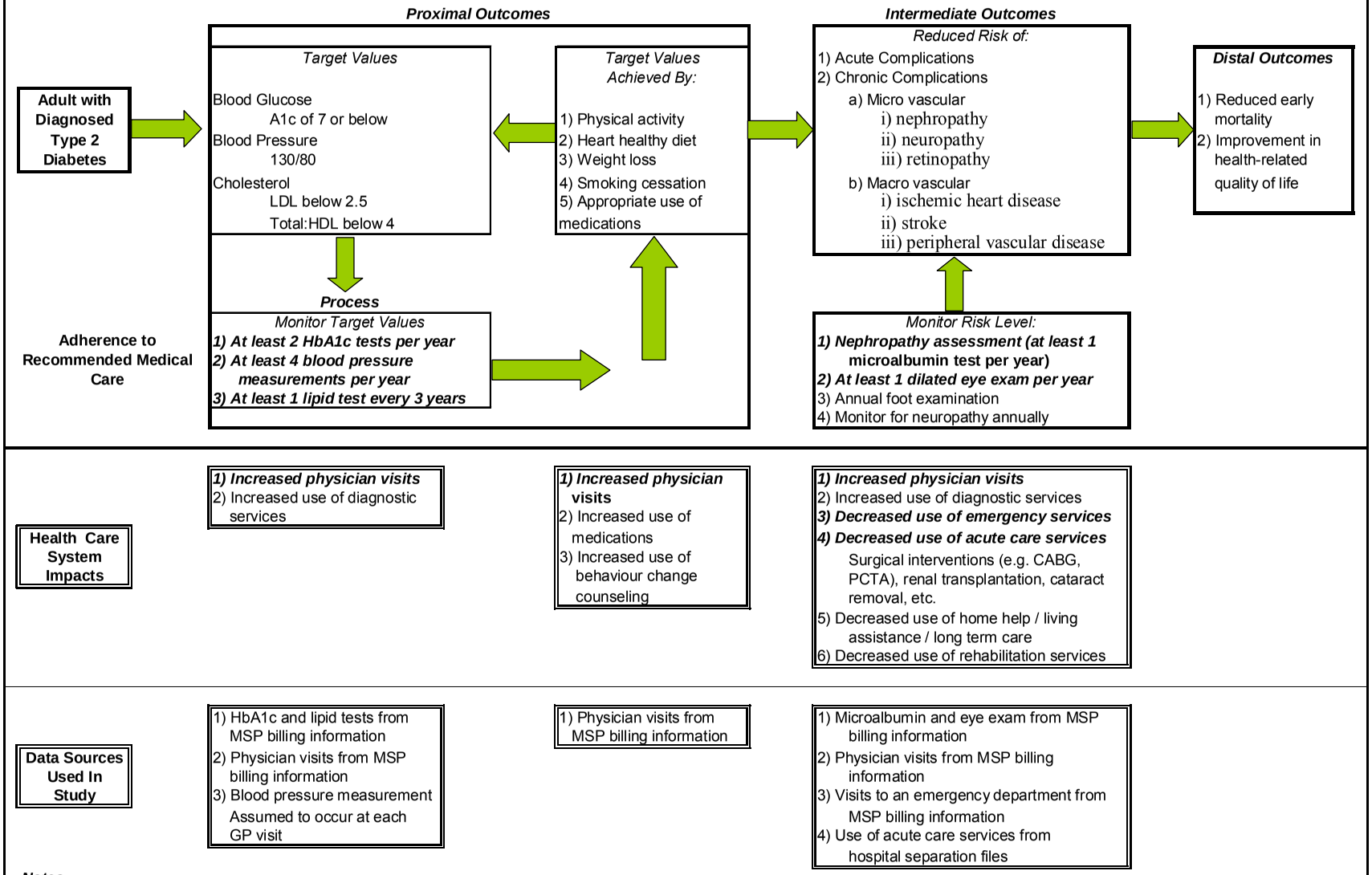
In patients with diagnosed type 2 diabetes, appropriate control of blood glucose, blood pressure and cholesterol levels results in a reduced risk of both acute and chronic complications. The process of controlling blood glucose, blood pressure and cholesterol levels requires a number of key steps:

1. Knowledge of ideal target levels
2. Monitoring of actual results
3. Implementation and maintenance of lifestyle changes and, if appropriate, use of medications
4. Ongoing monitoring and changes to arrive as close as possible to the ideal target levels over time.

This process requires an increased utilization of physician resources, diagnostic tests, behaviour change counselling and medications compared to a situation in which monitoring and subsequent changes do not take place. On the other hand, improved control of blood glucose, blood pressure and cholesterol levels leads to a long-term reduction in both acute and chronic complications and the acute care services required to address these complications. Ultimately, the process of improved control of blood glucose, blood pressure and cholesterol levels leads to a reduction in premature mortality and an improved health-related quality of life. This information is summarized in the conceptual framework shown in figure 3-1.

Figure 3-1: Conceptual Framework

For Patients / Physicians with High Adherence to Recommended Medical Care



Notes:

Recommended clinical procedures and health care system impacts tracked in this study are highlighted in ***bold/italics*** print.

Figure 3-1 provides a conceptual framework for patients who receive recommended clinical procedures. As noted previously, a significant number of patients with type 2 diabetes do not receive recommended clinical procedures. Without appropriate monitoring, neither patients nor physicians will be aware of any variance between ideal and actual blood glucose, blood pressure and cholesterol levels. In turn, it is also less likely that they will address the lifestyle changes or the medication adjustments that are needed in order to reduce the variance between ideal and actual levels. When recommended clinical procedures are not provided and appropriate lifestyle/medication adjustments are not made, patients are at a higher risk of both acute and chronic long-term complications necessitating an increased use of emergency, acute care, long term care and rehabilitation services. In addition, the patient is at an increased risk of early mortality and deterioration in health-related quality of life.

Specifically, this study used routinely-collected administrative data to determine whether adults with diagnosed diabetes with higher long-term adherence to recommended clinical procedures utilized a higher volume of physician services and a reduced volume of acute care services during the five years from April 1, 1996, to March 31, 2001, after adjusting for patient age, gender, socio-economic status, location of residence and levels of morbidity. The objective of this study is to determine if the delivery of appropriate diagnostic tests for diabetes is associated with elevated costs for physician visits and reduced costs for acute care.

The recommended clinical procedures for which routinely collected administrative data are available in British Columbia are highlighted in Figure 3-1 in ***bold/italicized*** print. This includes the tests for monitoring blood glucose, blood pressure, and cholesterol levels, and the tests used to assess for nephropathy and retinopathy. Furthermore, measures of health care utilization which are routinely available in administrative data in British Columbia are also

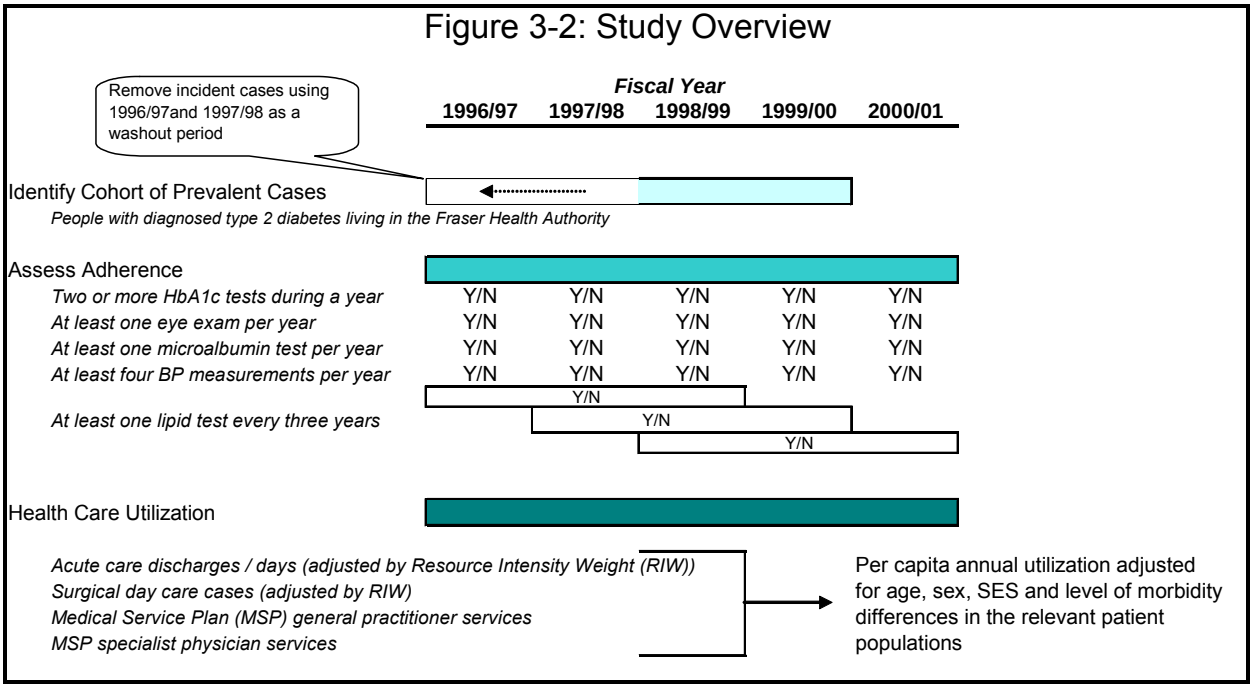
highlighted in ***bold/italicized*** print. The data sources used in this study are also summarized in figure 3-1.

A key assumption of this study is that actions necessary to bring blood pressure and blood glucose closer to ideal levels will be more likely if the patient undergoes the recommended type and frequency of tests than if the recommended tests are not performed. That is, on average, physicians providing the recommended tests are more likely to address unfavourable results than physicians not providing the recommended tests. In the same vein, it is assumed that patients who obtain unfavourable test results are more open to making changes than patients who are uninformed.

3.2 Study Design / Overview

This study is an observational, cross-sectional study with the individual as the unit of analysis. An overview of the study is shown in figure 3-2 below, with the various components discussed in the following sections.

Figure 3-2: Study Overview



3.3 Specific Aims and Hypothesis

Hypothesis: That the long-term receipt of appropriate clinical procedures for patients with diagnosed type 2 diabetes is associated with an increase in physician costs but a decrease in acute care costs.

Aim 1: To determine whether adherence to recommended clinical procedures for adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority has changed during the five years from April 1, 1996 to March 31, 2001.

Question 1.1 - Has the receipt of the following recommended services by adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority changed during the five years from April 1, 1996 to March 31, 2001?

- Two or more HbA1c tests during each fiscal year
- At least one eye exam during each fiscal year
- At least one microalbumin test during each fiscal year
- At least one lipid test every three years
- At least four blood pressure measurements each year

Question 1.2 – What proportion of adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority have received each of the five recommended services in each fiscal year?

Question 1.3 – What proportion of adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority received all five of the recommended services in each year during the entire five year time period (i.e., showed the highest adherence)?

Question 1.4 - What proportion of adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority received none of the five recommended services during the entire five year time period (i.e., showed the lowest adherence)?

The previous two questions represent the extremes of potential adherence.

Aim 2: To determine which patient characteristics (e.g. age, gender, socio-economic status, general level of morbidity, disease-specific severity level and geographic area of residence) are associated with improved long-term adherence to recommended clinical procedures.

Aim 3: To determine whether the utilization of physician and acute care services has changed during the five year period.

Aim 4: To assess the relationship between patient characteristics and the utilization of physician, acute care and total health care costs.

Aim 5: To determine whether adults with better adherence utilize varying levels of different types of health care, after adjusting for the patient's age, gender, socio-economic status, location of residence and levels of morbidity.

Question 5.1 – Do adults with better adherence use more physician services than those with poor adherence?

Question 5.2 – Do adults with better adherence use fewer acute care services than those with poor adherence?

Question 5.3 – Do adults with better adherence use fewer total services (physician and acute care) than those with poor adherence?

3.4 Data Sources

3.4.1 British Columbia Linked Health Database

Data for this study are drawn from the British Columbia Linked Health Database (BCLHD) housed by the Centre for Health Services and Policy Research (CHSPR) at the University of British Columbia. This is a linked longitudinal database including all residents of British Columbia who are registered with the Medical Services Plan. The BCLHD is an extensive data resource for applied heath services and population health research. Data from the BCLHD have been used for over one hundred health care and health services research projects since 1996.

The BCLHD includes data files containing:

- individual-level information on health care service use;
- claims made to the B.C. Workers' Compensation Board;
- basic information about the location and background of select health care service providers;
- surveys that provide a deeper level of understanding for (small) groups of B.C. residents; and
- descriptive information about neighbourhoods and communities derived from census data.

Where possible, the information from each data file in the BCLHD is linkable at the level of the individual. Data are linked using deterministic and probabilistic linkage methodology and linkage rates in excess of 95% have been achieved (Chamberlayne et al., 1998). These data can be used to explore population-based trends, allowing researchers to trace the experiences of groups of individuals across various arenas of the health system.

All data are anonymized to ensure protection of privacy and confidentiality. Specific data files used in this study are from the Medical Services Plan Registration and Premium Billing files, Medical Service Plan Payment Information Master files, the Hospital Separations files and the Vital Statistics - deaths files.

3.4.2 British Columbia Medical Services Plan Files

There are a number of potential sources of data for information on physician services and expenditures on physicians in British Columbia. These include the Medical Service Plan (MSP) database files, the MSP Out of Province (OOP) database, the Alternative Payment Program (APP) and the Primary Health Care Organization (PHCO) Encounter Data Set.

The MSP database files include fee-for-service (FFS) payments to B.C. physicians for services to B.C. and non-B.C. residents. It also contains payments made on behalf of B.C. residents who obtained services in Quebec, the U.S. and other countries (as these jurisdictions are not covered through reciprocal billing agreements).

The MSP Out of Province (OOP) database includes FFS payments made to out-of-province physicians who provided services to B.C. residents. When B.C. residents receive services in other provinces (except for Quebec), those other provinces bill back to B.C. manually – i.e., not through the standard claim submission process. This process is used as a result of the reciprocal agreements set up between and among the provinces. Thus, these payments are not included in the main MSP database, but are in this OOP database.

The Alternative Payment Program (APP) database includes salary, sessional payment, and service agreement data Note that salary and sessional data are physician-specific, but service agreement data are not.

The PHCO Encounter Data Set includes data from primary care demonstration sites established in the 1999/00 fiscal year.

Approximately 80% of B.C. physicians are self-employed professionals working on a fee-for-service (FFS) basis. In the FFS system, the MSP pays physicians an established fee for each service provided to each patient. Fees compensate physicians for their professional services and pay for overhead including staff salaries, medical equipment, supplies, rent, continuing education, insurance, business licenses, and other costs associated with running a business.

Physicians billing FFS must submit claims to MSP in a computer-readable format within 90 days of the service date. Claims can be submitted via Teleplan or by contracting with a service bureau equipped to make the submissions. Teleplan is a web-based telecommunications system used by practitioners to securely submit claims, notes and eligibility requests to MSP, and receive payment statements, rejected claims and patient eligibility data from MSP through an encrypted Internet connection.

A second group of physicians are paid through salaried or sessional arrangements. Salaried physicians are typically on staff at hospitals, private corporations, government agencies or universities. For example, medical directors of health authorities and physicians employed by the B.C. Cancer Agency, Riverview Hospital or Centre for Disease Control, and regional and provincial medical health officers, are salaried. Sessional payments are used primarily for physicians working in mental health and palliative care. The sessional payment is based on time, rather than service provided, with one session equalling 3.5 hours. This type of payment allows physicians to bill the MSP for the actual time spent with patients instead of the type of service or treatment provided.

The Alternative Payments Program (APP) administers the salaried or sessional payments to physicians. The Alternate Payments Program is in turn administered from within the MSP.

The APP salaried payments are made through the employing health care agency. These payments are based on submission of a "Claim for Reimbursement of Shareable Expenditure." Conditions for salaried physician payment are negotiated on a province-wide basis and set out in an agreement between the government of BC and the BCMA with respect to salaried physicians in government service.

The APP sessional payment provides funding to an agency, which in turn enters into a "Personal Sessional Contract" with a physician for the delivery of services. The agency is required to pay the physician directly for his/her time (based on a completed Certificate of Services form summarizing the amount of time required to deliver care services), and completion of a "Claim for Reimbursement of Shareable Expenditure" made to APP. Payment to the physician is made based on a proration of the standard 3.5-hour session rounded down to the nearest quarter hour. The sessional payment scale is negotiated between the BCMA and the Medical Services Commission (MSC).

Service agreements are used for physicians working solely in a publicly funded health care facility. For example, physicians working in emergency rooms or pathologists are typically paid through service agreements. Under a service agreement, regional health authorities and other government-funded agencies contract with physicians to deliver agreed-upon services / deliverables.

In addition to the major sources of physician payment (i.e., fee-for-service paid through MSP and salaried or sessional paid through APP), two minor sources include PHCO Encounter Data and BCMA-related funds. PHCO encounter funding is an encounter-based system that is

related to primary care practices, but does not contain physician-specific payments (i.e., payments go to practices that decide on dispersement). The fact that a service occurred, the date of the service and the diagnosis codes relating to that service, however, are available at the patient level in the PHCO Encounter Data. Finally, some funds are available to physicians through the BCMA (e.g., call reimbursement, Canadian Medical Physician Association fee repayment).

In the provision of primary health care in British Columbia, the vast majority of services are provided through MSP FFS payments. In 2000/01 spending on primary care physicians in the province totalled an estimated $664.0 million, of which $649.1 million (97.6%) was through the FFS system. In an analysis for residents living within the geographic boundaries of the FHA, this proportion of funding through FFS was 99.2% (Watson et al., 2004).

For specialist physician care a higher proportion of total expenditures are paid through the APP system than for primary care providers, particularly for certain specialities. Approximately 24% of psychiatry, 12% of oncology and 10% of paediatric services, for example, are funded through APP (Auditor General of British Columbia, 2003). In 2000/01, an estimated[1] 23% of total expenditures for specialist physicians was paid through the APP with the remainder (77%) paid through MSP.

The primary source for physician utilization and costs for this study is from the MSP files. This source provides comprehensive information on over 99% of all payments to primary care physicians and an estimated 77% of all payments to specialist physicians.

The Medical Services Plan Registration and Premium Billing files include information on the patient's gender, birth date, postal code, enrolment to and cancellation date from MSP. Medical Service Plan Payment Information Master files include additional information on the physician, the type and date of services billed as well as the amount paid for the services.

3.4.3 British Columbia Hospital Separations Files

All hospitals in British Columbia submit information on acute care and same day surgery separations to the Canadian Institute for Health Information (CIHI). Upon discharge from hospital, the patient's medical record is coded and abstracted based on criteria determined by CIHI. The resulting Discharge Abstract Database (DAD) abstract is submitted to CIHI where the data are edited for quality and additional information added (e.g., case-mix grouping, resource intensity weight, etc.). Hospital-specific reports are then produced and returned to the hospital for further review and corrections, prior to being used in the production of CIHI reports and distribution to the provinces (CIHI, 2004).

In recognition of the importance of data accuracy and quality, CIHI has instituted a variety of data control measures. These include the use of abstracting software, educational programs for abstractors, a production system editing and correction process as well as special studies assessing the quality of the data (CIHI, 2004). These special studies usually involve accessing the original data sources (i.e., medical records) and re-abstracting information to

[1] This estimate was developed in the following manner. PURRFECT Version 9.0 MSP Referral Patterns indicates that $1,766.1 million was spent on physician services through MSP in 2000/01. Of this amount, $649.1 was spent on GP services, leaving $1,117 million for 'other' services. From this amount we removed $130.2 million for non-medical practitioners and $359.4 for diagnostic specialists, leaving $627.4 million for specialist services. Total expenditures through APP totaled approximately $200 million in 2000/01 (Auditor General of BC, 2003).Of these funds, $11.9 million is allocated to primary care services (Watson et al., 2004). We have assumed that the remaining APP expenditures of $188.1 million are for specialist physician services. Based on these assumptions, an estimated 23% ($188.1 of $815.5 million) of specialist physician expenditures are paid through the APP.

compare with the original abstracted information (Long et al., 2001; Mitchell and Brown, 2002; Brown and Richards, 2002).

Despite this caution, data quality issues do surface. A review of the 1999/00 DAD indicated a discrepancy rate between the original and the re-abstracted information of 13.4% with respect to the *most responsible diagnosis* field, 10.0% for the *principal procedure* field, 9.0% for the *postal code* field, 6.5% for the *entry code* field and so on (Richards et al., 2001). The most common reasons for these discrepancies included the original coder missing information that was included in the medical chart and differences in the interpretation of the documentation (Richards et al., 2001).

3.4.4 British Columbia Vital Statistics Database

The British Columbia Vital Statistics Agency is responsible for the ascertainment, registration, and certification of vital events through the administration of the *Vital Statistics Act*, *Marriage Act* and *Name Act* (British Columbia Vital Statistics Agency, 2003). The Vital Statistics database was used to ascertain whether a patient in the study had died and the date of that death.

If a person dies in British Columbia, the death must be registered with the Vital Statistics Agency. The process is as follows. A medical practitioner or coroner will complete and sign a medical certificate within 48 hours after the death. The medical certificate will be forwarded to a funeral director. On the request of the funeral director, the particulars of the death are provided by an appropriate person, e.g., the nearest living relative present at the death or latest illness. The funeral director then registers the death and provides a death certificate and a burial permit for the deceased.

The British Columbia Vital Statistics Agency database does not include deaths for BC residents that occurred outside of the province (British Columbia Vital Statistics Agency, 2003).[2]

The BCLHD includes options to access Vital Statistics data on deaths, births and clinical information. For this study, we accessed data on deaths only. The date of death was identified by the year and month in which the individual died.

3.5 Study Population

The study patient cohort consists of all adults with diagnosed type 2 diabetes who lived continuously within the geographic boundaries of the Fraser Health Authority during the five year time period from April 1, 1996 to March 31, 2001 and who were not identified as incident cases. Additional exclusions from this cohort are noted below.

3.5.1 Ascertaining Diabetic Cases

While diabetes can be clinically defined based on plasma glucose values, determining the total number of people with diabetes in a population varies somewhat based on how cases are ascertained and whether or not estimates are included for undiagnosed cases. Accurate, population based estimates are important for both policy-makers and planners who influence the provision of resources and care for patients with diabetes.

The prevalence of diabetes has been ascertained using various methodologies such as:

- National population-based surveys (Tan and MacLean, 1995; Harris and Robbins, 1994)

[2] The fact of a death in another Canadian province of person borne in BC is reported electronically to BC. No other particulars are currently sent, though a system is under development. This process is intended to deter identify theft. Lorne Verhulst, personal communication, February, 2006.

- Registries (LaPorte et al., 1985), cohort studies in highly selected populations (Leibson et al., 1997)
- Medical record reviews (Martin et al., 2000)
- Standardized telephone surveys (Mokdad et al., 2000, 2001)
- Routinely collected administrative data (Blanchard et al., 1996; Hux et al., 2002).

Population based surveys in Canada such as the National Population Health Survey and the more recent Canadian Community Health Survey have facilitated population based estimates of prevalence using patient self-reporting. There is evidence, however, that self-reporting tends to underestimate the true prevalence of diagnosed diabetes (Manuel and Schultz, 2004; Hux et al., 2002; Mackenbach et al., 1996). Another disadvantage is that the cost of primary data collection at a national level can be high.

The use of routinely collected administrative data to ascertain the prevalence of diabetes is an approach that is considerably less resource intensive than other approaches and thus appropriate for ongoing surveillance. Blanchard and co-workers (1996) in Manitoba used comprehensive databases of physician service claims and hospital discharge abstracts to identify individuals diagnosed with diabetes in that province. Their algorithm specified that any patient with two physician service claims or one hospitalization with a diagnostic code of diabetes within a two year period would be identified as having diabetes. More recent work (Watson et al., 2003) in Manitoba used a similar algorithm but used two physician service claims or one hospitalization bearing a diagnosis of diabetes within a three year period.

Hux and colleagues (2002) in Ontario tested two algorithms for assessing the prevalence of diabetes using administrative data bases. They used the algorithm developed by Blanchard and co-workers (1996) as well as one which required only one physician service claim. They also

excluded gestational diabetes by identifying any record bearing a diabetes diagnostic code followed by an obstetrical event within 5 months after the date of the diabetes diagnostic code.

The results of these algorithms were validated by comparing them to the National Population Health Survey in which a random sample of the population was asked whether they had diabetes that had been diagnosed by a physician. In addition, primary chart abstraction was conducted on a random sample of 3,317 patients from 520 physicians. They concluded that using only a single physician service claim resulted in an unacceptable level of false positive identifications, possibly due to cases where diabetes was suspected but subsequent laboratory tests did not confirm this suspicion.

In British Columbia, the Chronic Disease Management group of the B.C. Ministry of Health Services has used the following case definition in determining the number of individuals in the province with diagnosed diabetes:

- At least one hospital discharge coded as ICD-9 250 since April 1, 1992, based on three levels of care (acute, rehabilitation, and day care), and all 16 hospital diagnoses; or
- At least two Medical Service Plan services (on different dates) coded as ICD-9 250 within a moving 365 day period; or
- At least one pharmacare service: glucose testing strips (98995003), oral hypoglycaemics (682020012-682092002 and 682092021-682092043), or insulin (682008).
- Remove gestational diabetes cases: delete hospital, MSP, and pharmacare/pharmanet records that occur five months prior and three months after delivery (admission) dates.

For this study, the initial study population was identified based on Medical Service Plan claimants who had resided within the geographic boundaries of the Fraser Health Authority at any time between April 1, 1996 and March 31, 2001. These patients met the following criteria:

- had at least one hospital discharge coded as ICD 9-250 in any of the 16 diagnostic fields between April 1, 1998 and March 31, 2000 , or,
- had at least one MSP service coded as ICD 9-250 between April 1, 1998 and March 31, 2000.

This initial draw resulted in a population of 64,020.

3.5.2 MSP Exclusions

MSP claims associated with non-physician specialties were excluded (see Table 3.1).

Table 3-1: Excluded Non-Physician Specialties	
30 – Chiropractor	31 – Naturopath
32 – Physiotherapist	34 – Osteopath
35 – Orthotics	37 – Oral Surgery
38 – Podiatry	39 – Optometry
40 – Dental Surgery	41 – Oral Medicine
42 – Orthodontics	43 – Massage Therapy
80 – Midwife	81 – Registered Nurse
82 – Nutritionist / Dietician	83 – Counsellor
84 – Educator	85 – Licensed Practical Nurse
86 – Medical Office Assistant	87 – Nurse Practitioner
88 – Respiratory Therapist	89 – Home Support

In addition, unknown fee item codes, mileage fee item codes, anaesthesia and dentistry fee item codes, records with no payment information and records for out-of province patients were excluded. These MSP exclusions resulted in the reduction of 168 individuals from the initial population of 64,020.

3.5.3 Diagnostic Rule-Outs

A sub-group of individuals identified included those who only had one MSP service coded as ICD 9-250 between April 1, 1998 and March 31, 2000. These were individuals who fell outside of the 'standard' algorithm for identifying a person with diabetes using administrative databases. As noted earlier, Hux and colleagues (2002) tested algorithms which included either one or two physician service claims identified as ICD 9-250 over a two year period. They found that using only a single physician service claim resulted in an unacceptable level of false positive identifications, possibly due to cases where diabetes was suspected but subsequent laboratory tests did not confirm this suspicion. This process resulted in the exclusion of 18,054 individuals from the initial population of 64,020.

3.5.4 Children

Children, particularly adolescents, with diabetes tend to have different care patterns than adults. Adolescents, for example, experience poor glycaemic control and acute complications more frequently than adults (DCCT, 1994; Svoren et al., 2003). Potential reasons for this include changing physiology (pubertal growth and development) as well as behavioural and adherence issues (Amiel et al., 1986; Wysocki et al., 1996; Rydall et al., 1997; Wolfsdorf, 1999). Individuals who were under the age of 20 years on April 1, 1996 were identified as children and excluded from the initial population. This process resulted in the exclusion of 800 individuals from the initial population of 64,020.

3.5.5 Gestational Diabetes

To exclude individuals with gestational diabetes, all females who had an obstetrical event within five months after a hospital or MSP ICD 9-250 code were identified. An obstetrical event

was identified using ICD 9 codes 630.0 to 676.9 based on a search of both hospitalization and MSP data. Only individuals for whom this was the only time that the ICD 9-250 code appeared were excluded. This process resulted in the exclusion of 1,106 individuals from the initial population of 64,020.

3.5.6 Incident Cases

To exclude incident cases (i.e., newly diagnosed cases), any individual *without* at least one hospital discharge coded as ICD 9-250 in any of the 16 diagnostic fields during the two year period between April 1, 1996 and March 31, 1998, or, at least one MSP service coded as ICD 9-250 during the two year period between April 1, 1996 and March 31, 1998 was identified and removed from the initial population. This process resulted in the exclusion of 12,569 individuals from the initial population of 64,020.

3.5.7 Death

Individuals who died were identified to take into account an increase in health care utilization during the time period prior to death. Between April 1, 1996 and March 31, 2001, a total of 3,268 individuals died.

3.5.8 Temporary Residents

Individuals who did not live within the geographic boundaries of the Fraser Health Authority for the entire five years from April 1, 1996 to March 31, 2001 were also identified. This was done because one of the control variables in the study was location of residence within the Fraser Health Authority. Of the 28,055 individuals remaining in the study population, 3,584 residents spent at least part of the five year time period living outside of the geographic boundary of the FHA, so they were removed from the analysis.

3.5.9 Temporary MSP Registration

A further sub-group of individuals identified was those who were not registered with MSP during the entire five years from April 1, 1996 to March 31, 2001. One of the key outcome variables in the study was utilization of health care services, particularly those identified through MSP and hospitalization data, during the entire five year time period. Consequently, a total of 1,782 individuals with temporary MSP registration were removed.

3.5.10 Exclusion of Disease and Age-Specific Sub-Groups

There were a number of patient sub-groups included in the remaining population of 22,689 for whom adherence to recommended clinical procedures might have been unusual for clinical reasons. Arday and co-authors (2002), for example, found that the End Stage Renal Disease (ESRD) subpopulation in their study had much lower rates of adherence to recommended clinical procedures than the general population with diagnosed diabetes. The authors noted that clinicians were dealing with "an elderly or disabled population with competing co-morbidities that may influence diabetes care decisions." For individuals with high impact cancers and Acquired Immune Deficiency Syndrome (AIDS), the potentially life-saving medical care associated with these diseases would likely usurp the imperative, for example, to have blood glucose levels monitored on a regular basis. We identified and excluded patients with type I diabetes, high impact cancers, AIDS, ESRD and the very old.

Type 1 and type 2 diabetes are distinct clinical entities, as noted earlier. Unfortunately, there is no reliable way to identify these two populations from the administrative data without the availability of two-digit suffix coding (i.e. ICD9-250.01, 'type 1 diabetes mellitus'). In the absence of this detailed coding information, researchers made the distinction using age 30 as a cut off point because type I diabetes is usually diagnosed early in life whereas type 2 diabetes

typically develops later in life. A study by Laakso and Pyorala (1985) indicated that the cumulative proportion of prevalent cases of type 1 diabetes in Finland was 84% at age 30 and 95% at age 50. More recent research (Fagot-Campagna and Narayan, 2001; Duncan, 2006) pointing to the increasing prevalence of early onset type 2 diabetes makes the 30 year cut-off point less reliable. Nevertheless, we have used the age 30 cut-off point as an exclusion criterion.

Patients with AIDS were identified based on the presence of the ICD9 code 042 in either the MSP or hospitalization data between April 1, 1998 and March 31, 2000. Patients with high impact cancers were identified based on the presence of the expanded diagnostic cluster (EDC) MAL03 code between April 1, 1998 and March 31, 2000. Patients with end stage renal disease (ESRD) were identified based on the presence of the EDC REN01 code between April 1, 1998 and March 31, 2000 (Weiner, et al, 2005). The very old were identified as individuals age 80 or older on April 1, 1998. This age cut-off for the very old in diabetes research follows the criterion established by the Manitoba Center for Health Policy Research (Fransoo et al., 2005).

This process resulted in the exclusion of the following number of patients:

- Age 80 or older – 1,542
- Younger than age 30 – 290
- Individuals diagnosed with high impact cancers – 330
- Individuals diagnosed with ESRD – 282
- Individuals diagnosed with AIDS – 3

The resulting study population was thus further reduced from 22,689 to 20,242.

3.5.11 Outliers

Fourteen individuals were removed from the analysis based on their high resource use over the entire five year period. This included one individual with an average of 194.6 acute care

days each year over the five year period (the next highest value was an average of 88.8 acute care days each year, see Figure 3-3), ten individuals whose average annual utilization of GP visits ranged from 75.8 to 119.0 for each year of the five year study period (see Figure 3-4) and three individuals whose average annual utilization of specialist visits ranged from 47.2 to 52.2 (see Figure 3-5). On visual inspection of the data, these fourteen subjects were considered to be outliers and removed from further analysis.

Figure 3-3: Identification of Outliers
Acute Care Utilization

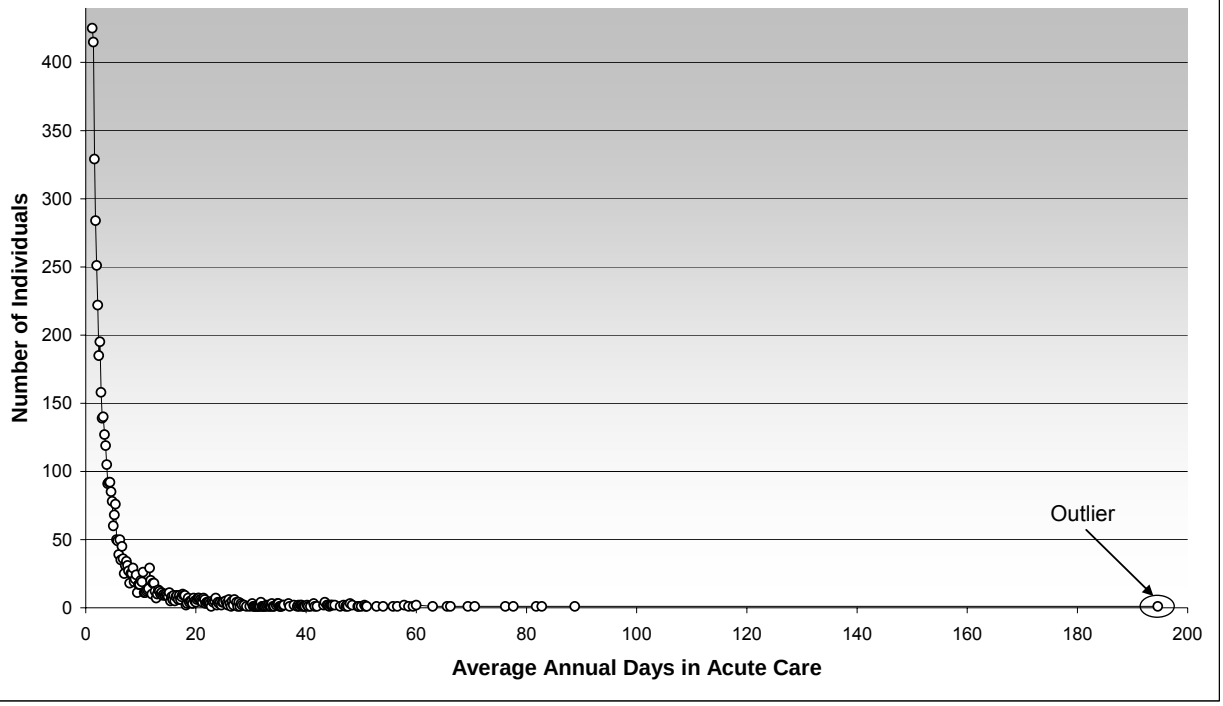


Figure 3-4: Identification of Outliers
General Practitioner Utilization

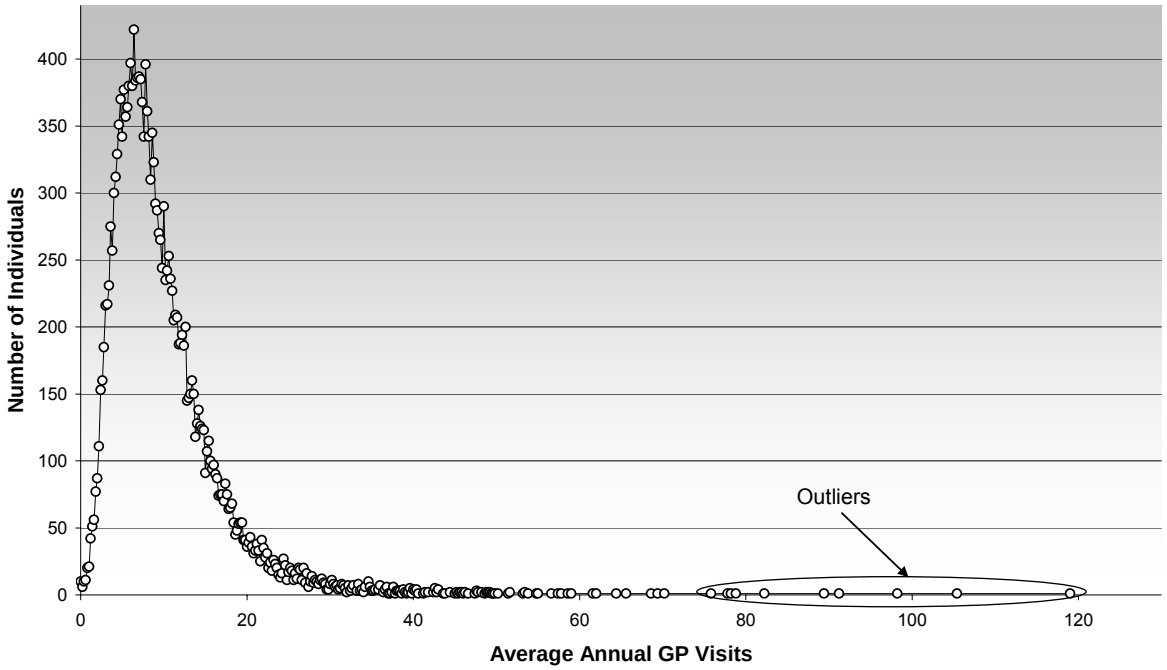
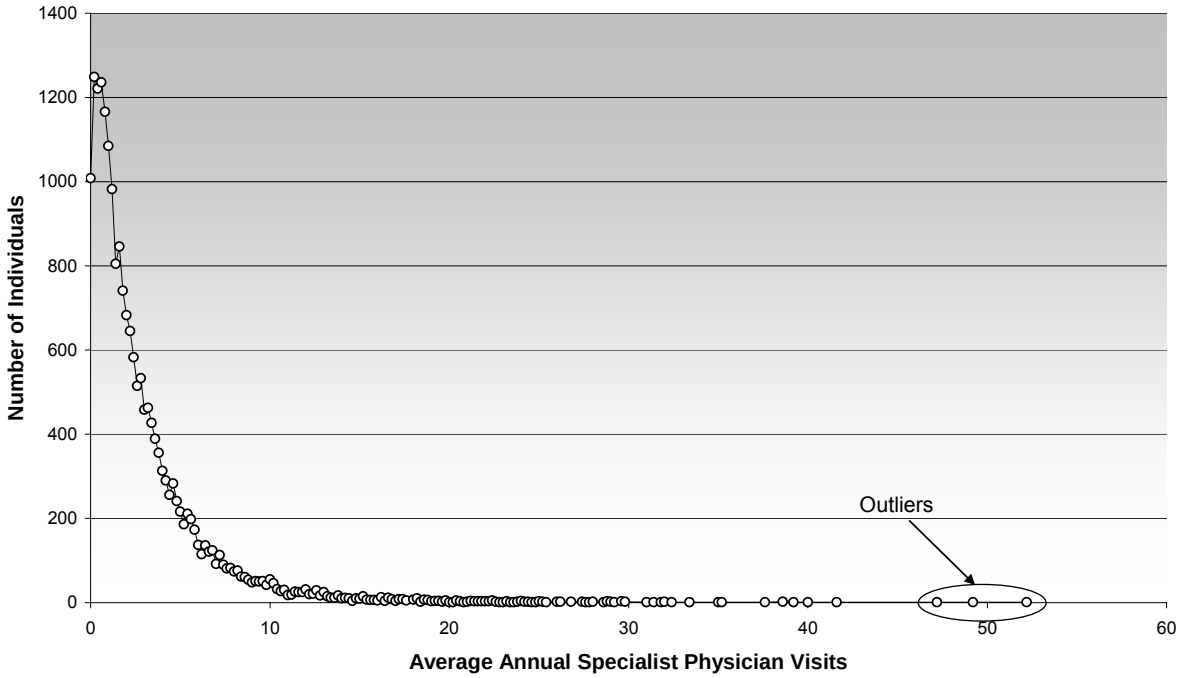


Figure 3-5: Identification of Outliers
Specialist Physician Utilization



3.5.12 Summary

The final study population consists of 20,228 individuals. A summary of the study selection process and results is shown on Figure 3-6.

Figure 3-6: Selection of Study Population

	Exclusions	Target Population Number	% of Total	Remaining Number
Include all MSP claimants who have resided within the geographic boundary of the Fraser Health Authority (FHA) between April 1, 1996 to March 31, 2001 (and have at least one hospital discharge coded as ICD 9-250 in any of 16 diagnostic fields, or, at least one MSP service coded as ICD 9-250 between April 1, 1998 and March 31, 2000).		**64,020**	**100%**	
Exclude individuals with an ICD-9 250 code only in the following records: non-physician specialty codes, non-physician fee item codes, unknown fee item codes, mileage fee item codes, anesthesia and dentistry fee item codes, records with no payment information and records for out-of-province patients.	**MSP Exclusions**	168	0.3%	63,852
Exclude individuals **with** only one MSP service coded as ICD 9-250 between April 1, 1998 and March 31, 2000.	**Diagnostic Rule-Outs**	18,054	28.2%	45,798
Exclude individuals under the age of 20 as of April 1, 1996.	**Children**	800	1.2%	44,998
Exclude females **with** an obstetrical event within 5 months after a hospital or MSP ICD 9-250 code, if this is the only time that the ICD 9-250 code appears.	**Gestational Diabetes**	1,106	1.7%	43,892
Exclude individuals **without** at least one hospital discharge coded as ICD 9-250 in any of 16 diagnostic fields, or, at least one MSP service coded as ICD 9-250 between April 1, 1996 and March 31, 1998.	**Incident Cases**	12,569	19.6%	31,323
Exclude individuals who died during the time period from April 1, 1996 to March 31, 2001.	**Death**	3,268	5.1%	28,055
Exclude individuals who did not live in the geographic boundary of the FHA during the entire time period from April 1, 1996 to March 31, 2001.	**Temporary Residents**	3,584	5.6%	24,471
Exclude individuals who were not registered with MSP during the entire time period from April 1, 1996 to March 31, 2001.	**Temporary Registration**	1,782	2.8%	22,689
Exclude individuals 80 years of age and older as of April 1, 1998.	**Elderly**	1,542	2.4%	21,147
Exclude individuals under the age of 30 as of April 1, 1998.	**Type I Diabetes**	290	0.5%	20,857
Exclude individuals with high impact cancers (n=330), ESRD (n=282) and AIDS (n=3).	**High Impact Diseases**	615	1.0%	20,242
Exclude statistical outliers based on high resource use during entire five year period.	**Outliers**	14	0.0%	20,228
Study Population		**20,228**	**31.6%**	

3.6 Variables and Measures

3.6.1 Adherence Variables

The key independent variable is the level of adherence to a set of recommended tests and procedures. The set of variables that will be measured, and their operational definitions, are as follows:

- HbA1c – Whether or not the person received two or more HbA1c tests during the fiscal year as identified by the MSP fee item 91745 (haemoglobin A1C). There will be five observations, one for each fiscal year from April 1, 1996 to March 31, 2001.
- Microalbumin – Whether or not the person received one urinary microalbumin test during the fiscal year as identified by MSP fee items 92396 (microalbumin, semi-quantitative) or 91985 (microalbumin). There will be five observations, one for each fiscal year from April 1, 1996 to March 31, 2001.
- Lipid – Whether or not the person had one lipid test over a three year period as measured by MSP fee items 91375 (cholesterol, total), 91780 (HDL cholesterol) or 92350 (triglycerides, serum/plasma). There will be three observations, one for the three year period from April 1, 1996 to March 31, 1999, one for the three year period from April 1, 1997 to March 31, 2000 and one for the three year period from April 1, 1998 to March 31, 2001.
- Eye exam – Whether or not the person had one eye exam during the fiscal year as measured by MSP fee items 2010 (consultation – ophthalmology), 2015 (eye examination), 2039 (fundus photography), 2040 (retinoscopy under general anesthetic), 2898 (re-examination or minor exam) or 2899 (full optometric

diagnostic). There will be five observations, one for each fiscal year from April 1, 1996 to March 31, 2001

- Blood pressure measurements – Information on whether or not an individual with diagnosed diabetes had a blood pressure measurement is not directly available in the administrative data. The Canadian and British Columbia CPGs have indicated that blood pressure should be measured at every physician visit and that this should occur at least four times per year. In this study, we have used the presence of at least four general practitioner (GP) visits in a fiscal year as a proxy for direct information on the appropriate number of annual blood pressure measurements. There will be five observations, one for each fiscal year from April 1, 1996 to March 31, 2001.

Information on the receipt of these tests/procedures over the five year period from April 1, 1996 to March 31, 2001 was combined to develop a measure of adherence. Each individual in the study population of 20,228 had 23 possible opportunities for these tests. Specifically, if all the recommended tests were received at appropriate intervals, the patient could earn 23 points during the five year period. Adherence points were assigned in the following manner:

- 1 point for two or more HbA1c tests per year, to a total of 5 points
- 1 point for at least one urinary test each year, to a total of 5 points
- 1 point for an eye exam each year, to a total of 5 points
- 1 point for at least four blood pressure measurements per year, to a total of 5 points
- 1 point for a lipid test during 1996-1999; 1 point for a lipid test during 1997-2000; and 1 point for a lipid test during 1998-2001, to a total of 3 points

Thus, an individual with perfect adherence on all five measures would be assigned a score of 23. On the other hand, an individual who received none of these tests or procedures over the five year period was assigned a value of 0. All others received a score between 0 and 23, depending on their receipt of the recommend tests or procedures over the five year period.

Weighting all tests equally follows the convention of the majority of research in this area, including the landmark research by McGlynn and colleagues (McGlynn et al., 2003; Asch et al., 2004; Asch et al., 2006). These researchers, for example, used 439 indicators to assess the quality of care provided for 30 different conditions. Each of the indicators received an equal weight, thus allowing the researchers to identify the proportion of recommended procedures received overall as well as for each specific condition.

The adherence score assigned to each individual was utilized to create three summary adherence variables; first, an adherence variable with continuous values from 0 to 23, second, an adherence variable with the categorical values of low, medium and high adherence and third, a binary adherence variable with the values of low or high adherence.

To determine the best clustering of these values into categorical (low, medium and high adherence) and binary variables (low or high adherence), we used the Jenks optimization algorithm (Environmental Systems Research Institute, Inc., ArcView GIS 3.3, 1992-2002). This method is based on an algorithm developed by Fisher (1958) and belongs to a class of clustering procedures designated as methods of partition by exact optimization (Hartigan, 1975). The Jenks method is used to create a grouping or partition of N objects into K non-intersecting subsets – P(N,K) – in such a way that an error function – e[P(N,K)] – is minimized. The method guarantees a partition with the smallest possible within-group variance for a given K value. The Jenks optimization algorithm indicated a clustering of scores from 0 to 9 (low adherence), 10 to

14 (medium adherence) and 15 to 23 (high adherence). The clustering for the binary variable was from 0 to12 (low adherence) and 13 to 23 (high adherence).

The adherence variables, and their data source, are identified on table 3-2.

Table 3-2 Adherence Variables

Variable	***Description***	***Values***	***Properties***	***Data Source***	***Status***
Individual Adherence Variables					
HbA1c Test	MSP fee items 91745	2 or more tests per fiscal year	Binary (yes/no)	MSP Payment Information Master Files	Modify
Microalbumin Test	Either MSP fee item 92396 or 91985	1 per fiscal year	Binary (yes /no)	MSP Payment Information Master Files	Modify
Lipid Test	Any of MSP fee items 91375, 91780, or 92350	1 every three fiscal years	Binary (yes/no)	MSP Payment Information Master Files	Modify
Eye Exam	Any of MSP fee items 2010, 2015, 2039, 2040, 2898, or 2899	1 per fiscal year	Binary (yes/no)	MSP Payment Information Master Files	Modify
Blood Pressure Measurements	General Practitioner Visits	4 or more GP visits per fiscal year	Binary (yes/no)	MSP Payment Information Master Files	Modify
Summary Adherence Variables					
Adherence Score I	Receipt of the 5 process variables over the five year period	0 to 23	Continuous	Created	Derived
Adherence Score II	Receipt of the 5 process variables over the five year period	Low (0-9), Medium (10-14), High (15-23)	Ordinal	Created	Derived
Adherence Score III	Receipt of the 5 process variables over the five year period	Low (0-12), High (13-23)	Binary	Created	Derived

3.6.2 Patient Characteristics

There are a number of known patient characteristics which have an independent influence on the utilization of health care services and may influence adherence to recommended clinical

procedures. These include age, gender, socio-economic status, location of the patient residence, general level of co-morbidity and diseases-specific severity.

The calculation of age was based on the individual's age on the first day (April 1, 1996) of the five-year study period. An additional year was added to the individual's age for each subsequent fiscal year. Age was included as both a continuous and a categorical variable. The categorical variable was developed by grouping individuals into the following age categories for each fiscal year:

- Ages 30 to 39
- Ages 40 to 49
- Ages 50 to 59
- Ages 60 to 69
- Ages 70 to 79

Income quintiles by neighbourhood were used as a proxy for socio-economic status. The Centre for Health Services and Policy Research uses a methodology developed by Ng et al. (1997). Ng and co-authors developed an Income Per Person-Equivalent (IPPE) which "takes into consideration the economies of scale possible when two or more people share a household" (p.22). Enumeration area (EA) income information is available from census data including the average household income (total EA income divided by the number of private households in that EA) and average personal income (total EA income divided by the population aged 15 and over in the EA).These calculations, however, do not take into account the number of persons per household.

> Two people sharing a residence do not require twice the income of a person living alone to maintain the same standard of living. Thus, an EA with relatively low average personal income, but many multi-person households, may have a standard of living similar to an EA with relatively high average personal income but with many one-person households. The calculation of IPPE adjusts average household income for the bias introduced by the unequal distribution of household sizes across EAs. (p. 22)

IPPE is calculated as follows:

- IPPE = total household income in an EA / person-equivalents
- Where person-equivalents =

    1.00 (number of one-person households) +

    1.36 (number of two-person households) +

    1.72 (number of three-person households) +

    1.98 (number of four-person households) +

    2.30 (number of five- or more person households).

The income quintile categorization provides an ecologic measure of socioeconomic status for individuals residing in Fraser Health Authority neighbourhoods.

Location of a person's residence is based on linking the first three digits of the individual's postal code to the geographic area designated by local health areas (LHAs). The Fraser Health Area consists of 13 distinct LHAs. Information on the LHA of residence was calculated for each of the five fiscal (April 1 – March 31) years. If an individual moved from one LHA to another they were allocated to the geographic region in which they lived for the majority of the fiscal year.

Information on an individual's residence is included as earlier work by H. Krueger & Associates Inc. (2003) indicated a significant variance in terms of the diagnostic care services received by people with diabetes living within the various FHA LHAs. Likewise, research in the United States has identified significant variation between residents of different states in the receipt of recommended services even after adjusting for patient-level characteristics (Jencks et al., 2000; Arday et al. 2002).

Adjusted Clinical Groups (ACGs) were used as a proxy for the level of morbidity. ACGs, were originally developed in the United States, as a measure of the burden of morbidity in populations. ACGs have been validated in the Canadian setting (Reid et al., 1999, 2002) and in particular, in British Columbia (Reid et al., 2001). These Canadian studies have found that ACGs explain about 50 per cent of same year physician costs and about 40 per cent of same year total medical and hospital costs.

The ACG case-mix system assigns the over 14,000 International Classification of Diseases (ICD) codes into 32 clinically similar aggregated diagnostic groups (ADGs) based on the following criteria:[3]

- Expected duration of illness (e.g., acute, chronic, or recurrent)
- Disease severity (i.e., expected prognosis with respect to disability or longevity)
- Diagnostic certainty (e.g., sign and symptoms versus well defined conditions)
- Etiology (e.g., infections, neoplasms, psychosocial conditions)
- Expected need for specialist care or hospitalization

This information is then combined with the patient's age and gender to assign each patient to one of 82 mutually exclusive adjusted clinical groups (ACGs).

There are a number of key advantages of using the ACG system as opposed to other methods to quantity the burden of morbidity in populations (e.g., self-reported health status, age and gender, measures of social deprivation, premature mortality rates, etc.). First, the ACG system "does not rely on only the most important or most common diagnosis, but instead identifies common combinations of morbidities (related and unrelated) that build upon each other, both additively and multiplicatively, to determine an individual's overall need for health

[3] The Johns Hopkins ACG® Case-Mix System, Version 5.0: Software Release Notes, Chapter 5, pages 41-43. Johns Hopkins University Bloomberg School of Public Health.

services" (Reid et al., 1999). Second, the main data elements required for the system – age, gender and diagnosis – are often routinely collected in administrative data systems and thus are available for total populations. Third, the ACG system assigns individuals to illness categories based on all of the diagnoses they receive over an extended period of time (e.g., one year) from multiple providers (e.g., hospitalizations, physician visits, ambulatory care procedures). And finally, because it "uses only diagnosis – not procedures or hospitalizations – to define illness levels, it does not reward practices that elect to hospitalize patients more readily or perform more procedures" (Verhulst et al., 2001).

A recent study by Broemeling and colleagues (Broemeling et al., 2005) used ACGs to identify the existence of co-morbidities in individuals with a confirmed chronic condition and then allocated individuals with the chronic condition to five categories depending on the number of co-morbidities experienced. The authors defined a co-morbidity as "the co-occurrence of additional conditions among individuals with an index condition (Broemeling et al., 2005)". One of the difficulties encountered was the distinction between complications and co-morbidities. Complications can be defined as "the existence of a second disease when the occurrence of an index disease is required (Gijsen et al., 2001)". Thus, diabetic retinopathy is a complication associated with diabetes while hypertension and depression are co-morbidities. While this is a fairly clear example of the distinction between complications and co-morbidities, the distinction between the two is often less clear.

In the Broemeling et al. study (2005), individuals with an index condition of diabetes were further assigned to five groups based on their co-morbidity level. The presence of co-morbidities was identified using ACGs. The five categories are as follows (see **Appendix A for a detailed listing of the ACGs in each of the five categories**):

1. Level 1 – Very low co-morbidity
2. Level 2 – Low co-morbidity (2 or 3 types of conditions)
3. Level 3 – Medium co-morbidity (4 or 5 types of conditions)
4. Level 4 – High co-morbidity (6 to 9 types of conditions)
5. Level 5 – Very high co-morbidity (10+ types of conditions)

For people with diagnosed diabetes, the proportion of this adult population in British Columbia in Levels 1 to 5 was 9%, 29%, 30%, 25% and 7% respectively. We have used the same approach as Broemeling et al. (2005) in assigning patients with diabetes to these five levels of morbidity.

A measure of disease-severity used in this study was the diabetes-specific disease severity index developed by Reid (1998). This methodology uses diabetes-related complications and pre-existing conditions which exacerbate diabetes management to group patients into the following five groups:

1. No complicating conditions
2. ≥ one minor complicating conditions
3. ≥ one intermediate complicating condition
4. One major complicating condition
5. ≥ two major complicating conditions

The group of *minor* complicating conditions were defined by Reid (1998) as hypertension, lipid disorders and chronic psychiatric disorders. Patients were classified as having a physician-diagnosed complicating condition if they had two or more claims with the relevant diagnosis. Diagnosis of the minor complicating conditions was based on the following ICD9 codes:

1. Hypertension

    - 401 – Primary hypertension
    - 402.4 – Hypertensive renal or heart disease
    - 405 – Secondary hypertension
    - 437.2 – Hypertensive encephalopathy
    - 796.2 - Elevated blood pressure

2. Disorders of Lipid Metabolism

    - 272 – Lipid disorders

3. Major Psychiatric Disorders

    - 295 – Schizophrenia
    - 296 – Major affective disorder
    - 297.9 – Other psychoses
    - 303.0 – Alcohol abuse
    - 304.0 – Drug dependence

The group of *intermediate* complicating conditions were defined as diabetic eye disease (i.e., including retinopathy, glaucoma, and cataract), neuropathy, and peripheral vascular disease. Patients were classified as having a physician-diagnosed complicating condition if they had two or more claims with the relevant diagnosis. Diagnosis of the intermediate complicating conditions was based on the following ICD9 codes:

1. Eye Disease

    - 250.5 – Diabetic retinopathy
    - 262 – Retinopathy
    - 365 – Glaucoma
    - 366 – Cataract
    - 379.3 – Lens Aphakia
    - 743.3 – Congenital cataract

2. Neuropathy

    - 250.6 – Diabetic neuropathy
    - 350.7 – Mononeuropathy or polyneuropathy
    - 377.1 – Autonomic neuropathy
    - 729.2 – Unspecified neuropathy

- 723 – Other neuropathy

3. Peripheral Vascular Disease

    - 440 – Atherosclerosis
    - 443 – Unspecified peripheral vascular disease
    - 785.4 – Gangrene

The group of *major* complicating conditions included two acute conditions (i.e., diabetic ketoacidosis and hyperosmolar non-ketotic coma) and two chronic conditions (i.e., kidney disease and ischemic heart disease). Patients were classified as having a physician-diagnosed complicating condition if they had two or more claims with the relevant diagnosis. Diagnosis of the major complicating conditions was based on the following ICD9 codes:

1. Acute Coma

    - 250.1 – Diabetic ketoacidosis
    - 250.2 – Hyperosmolar non-ketotic coma
    - 250.3 – Other coma

2. Renal Disease

    - 250.4 – Diabetic renal disease
    - 581 – Nephrotic syndrome
    - 582 – Glomerulonephritis
    - 583 – Other nephritis
    - 584 – Acute renal failure
    - 585 – Chronic renal failure
    - 586 – Unspecified renal failure
    - V56 – Dialysis care

3. Ischemic Heart Disease

    - 410 – Acute myocardial infarction
    - 411 – Subacute myocardial infarction
    - 412 – Old myocardial infarction
    - 413 – Angina pectoris
    - 414 – Coronary atherosclerosis

The algorithm developed by Reid (1998) was applied to the current study population to develop a diabetes-specific disease severity index variable.

The diabetes-specific disease severity index provided a measure of the level and severity of diabetes-specific complications while the general measure of morbidity using ACGs provided a gauge of the level of co-morbidities experienced by the patient, regardless of whether these co-morbidities were directly associated with the patient's diabetes.

These patient characteristics, and their data sources, are identified on table 3-3.

Table 3-3 Patient Characteristics

Variable	***Description***	***Values***	***Properties***	***Data Source***	***Status***
Age in Years	Age as at April 1 of each year	Age 30-79, unknown	Continuous, Categorical	MSP Registration and Premium Billing Files	Existing
Gender		Male, female, unknown	Binary (Male, Female)	MSP Registration and Premium Billing Files	Existing
Socio-economic status	Assign individuals to SES quintile	Assign to SES quintile each year based on residence, unknown	Ordinal	CHSPR derived	Existing
Level of Morbidity	Use co-morbidities to assign individual patients to one of 5 levels	Level 1 (very low morbidity), 2 (low morbidity), 3 (medium morbidity), 4 (high morbidity), 5 (very high morbidity) and 6 (pregnancy-related)	Ordinal	MSP Payment Information Master Files and Hospital Separations Files	Derived
Disease-specific Severity Index	Use disease-specific complications to assign individual patients to one of five levels	Level 1 (no complicating conditions), 2 (≥ one minor complicating conditions), 3 (≥ one intermediate complicating condition), 4 (one major complicating condition), 5 (≥ two major complicating conditions)	Ordinal	MSP Payment Information Master Files and Hospital Separations Files	Derived
LHA of patient residence	Local health area of residence in the FHA	Assign to one of 13 FHA LHAs each year	Categorical	MSP Registration and Premium Billing Files	Existing

3.6.3 Resource Use Variables

Previous research indicates that the utilization of health care services, particularly acute care inpatient services, can change within the first few years after the implementation of a comprehensive diabetes management program. We will examine the use of acute care and Medical Service Plan based health care utilization. The hypothesis is that acute care services, namely, acute care discharges / days (adjusted by Resource Intensity Weight {RIW}) and surgical day care cases (adjusted by RIW), will be lower in those patients with good diabetes management, as defined by better adherence to the recommended tests. On the other hand, general practitioner and specialist physician services (i.e., which are MSP based services) will be higher in those patients with more appropriate diabetes management.

3.6.3.1 Acute Care

In the hospital separations files used for this project, all separations (i.e. discharges and deaths) are identified as either acute, extended, rehabilitative care or surgical day care. In addition, some patients may be discharged from a discharge planning unit which means they have been receiving long-term care while in an acute care bed (sometimes identified as *alternate level of care*).

For acute care separations, we used separations identified as acute care only. That is, all records coded as 'A' (for acute) in the level of care field in the hospital separations file were included. Separations and the attendant patient days were allocated to each fiscal year based on the date of the patient's release from hospital. That is, if a patient was admitted on March 20, 1997 and discharged on April 10, 1997, then their discharge (and all patient days associated with the discharge) would be allocated to the 1997/98 fiscal year rather than the 1996/97 fiscal year.

Because of this assumption, it was possible for an individual patient who remained in hospital for more than a year to have 365+ patient days allocated to the year of their discharge.

Information on acute care inpatient days was used to create both a continuous and a binary variable. The binary variable was created by assigning an individual's annual acute care inpatient day utilization to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest utilization of acute care days in the year were assigned to the low utilization category while the 20% of patients with the highest utilization of acute care days in the year were assigned to the high utilization category. This process was used for each of the five fiscal years. The mean annual utilization was calculated using the individual's utilization history during the entire five years.

An additional outcome variable was the calculation of acute care costs. In calculating these costs we combined information on both acute care inpatient services and surgical day care services received by individuals in the study. For surgical day care procedures, all records coded as 'S' (for surgical day care) in the level of care field in the Hospital Separations file were included. Surgical day care "is a surgical service provided to patients who do not require inpatient services, are admitted and discharged on the same calendar day and are usually discharged between one and six hours following the procedure" (PURRFECT 10.1)[4]

In addition to information on the number of discharges and days for acute care inpatients, information on the resource intensity weighting assigned to each acute care inpatient discharge by the Canadian Institute for Health Information (CIHI) was gleaned from the hospital separations files. Similar information was available for each surgical day care procedure.

[4] PURRFECT (Population Utilization Rates and Referrals For Easy Comparative Tables) is an electronic database updated annually by the BC MoH and distributed to interested parties in British Columbia.

Resource intensity weights or RIW values are calculated by CIHI in the following manner.[5] As noted earlier, each hospital in British Columbia prepares a discharge abstract database (DAD) abstract for every discharge and submits this to CIHI. Based on information in the DAD abstract, the *discharge* is assigned to a case mix group (if they received acute inpatient care) or to a day procedure group (if they received a surgical day care procedure) based on the patient's most responsible diagnosis.

Three additional elements are assigned to each acute care inpatient discharge (Hicks and Zhang, 2003). First, information on co-morbid conditions present either at the time of admission or realized during the inpatient stay are used to assign each *discharge* to a complexity level. Cases are assigned to one of four levels. Level 1 denotes the absence of co-morbid conditions, while Level 4 denotes the presence of co-morbid conditions that may be potentially life threatening. Second, the expected length of stay is calculated based on the length of stay of similar discharges across Canada. Finally, cases are assigned to a typical and atypical category. Atypical cases include all deaths while in hospital, individuals who sign themselves out against a physician's advice, those transferred from one hospital to another and long-stay outliers. All other cases are considered to be *typical*.

Information on the assigned case-mix group, complexity level, expected length of stay, typical/atypical status and the patient's age (i.e., three age categories [0–17, 18–69, 70+]) were used in assigning an RIW to each discharge case. "RIW are used to standardize the expression of hospital case volumes, recognizing that not all patients require the same health care resources. Volume is then expressed as *weighted cases*".[6]

[5] See http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=casemix_riw_e (Accessed October 2005) for more information.
[6] Ibid.

Each acute care inpatient and surgical day care procedure in British Columbia is thus assigned a resource intensity weight indicating the expected level of relative resources used in caring for the patient compared to other patients.

The B.C. Ministry of Health Services uses CIHI's methodology for calculating a cost per weighted case for each hospital in the province.[7] In essence, this involves teasing out costs associated with inpatient acute care services and then dividing these costs by the volume of weighted acute care cases treated at the hospital level. This generates a hospital specific cost per weighted case. In 2000/01, the calculated cost per weighted case in hospitals located within the Fraser Health Authority ranged from $2,150 to $3,520. The provincial average that year was $3,440.[8] Since we used all acute care discharges and surgical day care procedures in this study, regardless of the hospital in which they were performed, we used the provincial average of $3,440 in estimating the cost of providing acute and surgical day care services to the patient population in this study. To standardize costs to the 2000/01 fiscal year, we multiplied the weighted case value for each patient's use of acute inpatient or surgical day care services in each of the five years by the $3,440.

There are a number of ways to estimate patient-specific acute care costs. Perhaps the most crude is to multiply patient days by the hospitals average cost per patient day. This does not take into account differences in the complexity of care provided to patient groups. Arguably the most precise manner is to generate patient specific case costs based on actual resources used by individual patients multiplied by the cost per unit of resource use. Several hospitals within B.C. have moved in this direction by implementing case costing methodologies. Two of these hospitals have published results of a comparison of using RIW in estimating costs compared to

[7] Stephen Lee, Information Consultant, Information Resource Management, B.C. Ministry of Health, Personal communication, September 29, 2005.

their case costing methodology. The two hospitals are located in Victoria (Poole et al., 1998) and Vancouver (Borsa and Anis, 2005). For the Victoria hospital the results of the comparison suggested a relatively close approximation of costs calculated using these two methodologies (Poole et al., 1998) whereas greater variability was found for the Vancouver hospital (Borsa and Anis, 2005).

In the absence of case costing methodologies at all of the hospitals utilized by the sample of patients in this study, we have used a cost per weighted case as a closer approximation of actual costs than using a cost per patient day.

Information on acute care costs was used to create both a continuous and a binary variable. The binary variable was developed by assigning an individual's annual acute care costs to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest utilization of acute care costs in the year were assigned to the low utilization category while the 20% of patients with the highest utilization of acute care costs in the year were assigned to the high utilization category.

This process was used for each of the five fiscal years. A mean annual utilization was calculated using the individual's utilization history during the entire five years.

3.6.3.2 General Practitioner

Physician specialties can be identified in a number of ways. The most familiar methodology is by most recent registered specialty (MRRS) as designated by the physician's most recent specialty registration with the Medical Services Plan. This is a self-reported measure of each physician's licensure and registration status.

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[8] Ibid.

In contrast, type of practice (TOP) is a methodology that uses each physician's billing information to categorize the physician based on the way they actually practice. For example, a physician could report their MRRS as a family physician, but may actually have a billing pattern more closely representing emergency medicine. He or she would be identified as an emergency medicine physician by type of practice, despite their registered status as a family physician. By comparison, a physician could report their MRRS as pediatrics, but may actually have a billing pattern more closely representing a family physician. He or she would be identified as a family physician by type of practice, despite their registered status as a pediatrician. BC's Medical Services Plan uses the TOP methodology for publishing practitioner profiles (Verhulst and Starr, 2003).

Fee item specialty is a third type of methodology that identifies different types of services. All services covered under the Medical Services Plan are identified by particular fee items in the MSC payment schedule used by fee-for-service physicians. These fee items are grouped into broad categories, and different types of physicians are said to "own" a section for the purposes of fee negotiations. For example, fee item *0532 electrocardiogram and interpretation for children under 2 years of age* is owned by specialty 14-paediatrics. Another such category is called "general practice" and specialty 00-family physicians own fee items in this area. This *ownership*, however, does not imply exclusive billing: any practitioner billing under the Medical Services Plan can bill any applicable fee item. The use of fee item specialty methodology, therefore, captures all billings in a particular category of the MSC payment schedule used by fee-for-service physicians, regardless of the type of physician who provided those services. PURRFECT, a BC Ministry of Health Services database uses fee item specialty

methodology to identify services provided by general practitioners, even though these services may be delivered by physicians who have other MRRS specialty designations.

In this study we use the most recent registered specialty (MRRS). For general practice this was '0 - General Practice'.

The MSP payment information master files used to calculate the number of GP visits (i.e., and charges associated with those visits) required '*cleaning*' in order to generate an accurate determination of costs and counts of the number of visits. This was due to the following issues associated with the raw data in the MSP payment information master files:

- Claims represented by multiple records
- No charge referral records
- Claims that were never paid
- Retroactive adjustments

The process of *cleaning* or *netting the claims* combines claim records and amounts that are determined to pertain to the same service on the same date from the same provider to the same patient. In addition to cleaning the costs paid out to physicians, this process also allows visits to be counted accurately.

Information on GP visits was used to create both a continuous and a binary variable. The binary variable was created by assigning an individual's annual GP visits to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest utilization of GP visits in the year were assigned to the low utilization category while the 20% of patients with the highest utilization of GP visits in the year were assigned to the high utilization category.

This process was used for each of the five fiscal years as well as for a mean annual utilization calculated using the individual's utilization history during the entire five years.

Information on both the number of patient-specific visits and the payments associated with those visits were generated from the raw data in the MSP payment information master files. In addition to using GP visits to create a continuous and a binary variable, we also used the information on payments to create a cost variable. Payment information in the MSP payment information master files is based on the year in which the payment was made. For comparative purposes with respect to differences in resource use, we needed to adjust for price increases.

Adjusting for price increases or inflation is based on actual fee item increases received by GPs and specialist physicians between 1996/97 and 2000/01 as calculated by the British Columbia Medical Association (BCMA).[9] Price increases for GP services between 1996/97 and 2000/01 were as follows:

- 2.72% change to adjust 1996/97 data to 2000/01 levels
- 4.98% change to adjust 1997/98 data to 2000/01 levels
- 3.48% change to adjust 1998/99 data to 2000/01 levels
- 1.27% change to adjust 1999/00 data to 2000/01 levels

In 1997/98, there was a decrease in fee item prices of 2.15% followed by modest increases each of the following three years (1.45% in 1998/99, 2.18% in 1999/00 and 1.27% in 2000/01). The appropriate price increases were applied at a patient-specific level each of the five years so that all GP costs were adjusted to reflect 2000/01 prices.

Information on GP payments was used to create both a continuous and a binary variable. The binary variable was created by assigning an individual's annual GP costs to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest utilization of GP costs in the year were assigned to the low utilization category while the 20% of

patients with the highest utilization of GP costs in the year were assigned to the high utilization category.

This process was used for each of the five fiscal years. A mean annual utilization was calculated using the individual's utilization history during the entire five years.

3.6.3.3 Specialist Physician

As noted earlier, we used the most recent registered specialty (MRRS) in identifying the specialty of physicians in this study. Table 3-4 follows a new categorization matrix established for the primary care project currently being completed by CHSPR in which all personnel potentially paid with MSP funds were grouped into five categories. In defining specialist physicians for this study, we combined categories II and III in Table 3.4.

[9] Mr. Jim Aikman, Director, Economics Department, BCMA, Personal communication, November 10, 2005.

Table 3-4 CHSPR Categorization Matrix for Personnel Funded Through MSP	
I. General Practice	
00 - Family Practitioner	
II. Primary Care Related Specialists	
05 - Obstetrics and Gynaecology	14 - Pediatrics
15 - Internal Medicine	24 - Geriatric Medicine
28 - Emergency Medicine	
III. Non-primary Care Related Specialists	
01 - Dermatology	02 - Neurology
03 - Psychiatry	04 - Neuropsychiatry
06 - Ophthalmology	07 - Otolaryngology
08 - General Surgery	09 - Neurosurgery
10 - Orthopedic Surgery	11 - Plastic Surgery
12 - Cardio & Thoracic Surgery	13 - Urology
16 - Radiology	17 - Pathology
18 - Anesthesia	19 - Pediatric Cardiology
20 - Physical Medicine and Rehabilitation	21 - Public Health
23 - Occupational Medicine	29 - Medical Microbiology
33 - Nuclear Medicine	44 - Rheumatology
45 - Clinical Immunization and Allergy	46 - Medical Genetics
47 - Vascular Surgery	48 - Thoracic Surgery
IV. Non-physician Providers, Possibly Primary Care Related	
80 - Midwife	81 - Registered Nurse
82 - Nutritionist/Dietitian	83 - Counselor
84 - Educator	85 - Licensed Practical Nurse
86 - Medical Office Assistant	87- Nurse Practitioner
88 - Respiratory Therapy	89 - Home Support
91 - Pharmacy	
V. Non-physician Providers, Other	
30 - Chiropractics	31 - Naturopathy
32 - Physical Therapy	34 - Osteopathy
37 - Oral Surgery	38 - Podiatry
39 - Optometry	40 - Dental Surgery
41 - Oral Medicine	42 - Orthodontia
45 - Clinical Immunization and Allergy	

Information on both the number of patient-specific visits to a specialist physician and the payments associated with those visits were generated from the raw data in the MSP payment

information master files. The raw data for specialist physicians had to be *cleaned* in the same manner as the raw data for GPs.

Information on visits to a specialist was used to create both a continuous and a binary variable. The binary variable was created by assigning an individual's annual specialist physician visits to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest utilization of specialist physician visits in the year were assigned to the low utilization category while the 20% of patients with the highest utilization of specialist physician visits in the year were assigned to the high utilization category.

This process was used for each of the five fiscal years. A mean annual utilization was calculated using the individual's utilization history during the entire five years.

Payment information in the MSP Payment Information Master Files is based on the year in which the payment was made. For comparative purposes with respect to differences in resource use, we adjusted for price increases based on actual fee item increases received by specialist physicians between 1996/97 and 2000/01 as calculated by the British Columbia Medical Association (BCMA)[10] and applied these fee increases to actual specialist physician utilization in this study.

Table 3-5 provides a summary of price increases for specialist physician services between 1996/97 and 2000/01.

[10] Mr. Jim Aikman, Director, Economics Department, BCMA, Personal communication, November 10, 2005.

Table 3-5 Price Increases
For Specialist Physician Services
1996/97 to 2000/01

		MSP Fee Increase			
	Specialist	**1997/98**	**1998/99**	**1999/00**	**2000/01**
1	Dermatology	-3.33%	0.93%	2.07%	0.72%
2	Neurology	-3.24%	1.57%	2.27%	0.52%
3	Psychiatry	-2.77%	4.25%	2.22%	2.38%
5	Obs/Gyn	-2.23%	1.40%	2.25%	2.77%
6	Ophthalmology	-3.42%	0.97%	2.22%	0.52%
7	Otolaryngology	-3.28%	1.43%	2.13%	0.97%
8	General Surgery	-2.82%	1.10%	2.40%	0.60%
9	Neurosurgery	-2.84%	1.06%	2.40%	0.55%
10	Orthopaedic Surgery	-2.39%	1.03%	2.30%	0.52%
11	Plastic Surgery	-2.90%	1.02%	2.23%	0.52%
12	Cardiac Surgery	-3.15%	1.12%	2.52%	0.70%
13	Urology	-3.01%	0.98%	2.19%	0.52%
14	Paediatrics	-2.29%	4.24%	2.22%	4.45%
15	Internal Medicine	-2.75%	1.05%	2.27%	1.44%
16	Radiology	-2.68%	1.27%	1.15%	0.52%
17	Pathology	-2.44%	1.31%	0.69%	0.53%
18	Anaesthesia	-0.86%	2.85%	2.68%	0.52%
20	Physical Medicine	-3.58%	2.27%	2.24%	1.13%
28	Emergency Medicine	-3.88%	1.29%	2.59%	1.43%
44	Rheumatology	n/a	2.44%	3.52%	4.60%
47	Vascular Surgery	n/a	n/a	n/a	5.96%

These price increases were applied to the actual annual utilization of specialist physician services in this study to calculate a weighted increase for each year. The results are as follows:

- 2.02% change to adjust 1996/97 data to 2000/01 levels
- 4.96% change to adjust 1997/98 data to 2000/01 levels
- 3.58% change to adjust 1998/99 data to 2000/01 levels
- 1.29% change to adjust 1999/00 data to 2000/01 levels

The appropriate price increases were applied at a patient-specific level for each of the five years so that all specialist physician costs were adjusted to reflect 2000/01 prices.

3.6.3.4 Total Acute Care and MSP Costs

To this point, we have estimated the acute care and surgical day care resources used by each patient annually as well as an average annual utilization over the five year period from 1996/97 to 2000/01. In addition, we have determined patient specific resource utilization for

general practitioner and specialist physician services. All estimated costs and payments have been adjusted for price changes to 2000/01 fiscal year dollars. Estimated costs in these three areas (i.e., acute care, GP services and specialist physician services) were combined at the patient specific level to create a total estimated cost per patient for each fiscal year as well as an average annual utilization over the five year period from 1996/97 to 2000/01.

Information on estimated total acute care and physician costs was used to create both a continuous and a binary variable. The binary variable was developed by assigning an individual's annual costs to either a low or high utilization category based on an 80/20 rule. That is, the 80% of patients with the lowest costs in the year were assigned to the low utilization category while the 20% of patients with the highest costs in the year were assigned to the high utilization category.

This process was used for each of the five fiscal years as well as for a mean annual utilization calculated using the individual's utilization history during the entire five years.

The resource use variables, and their data source, are identified on table 3-6.

Table 3-6 Resource Use Variables					
Variable	***Description***	***Values***	***Properties***	***Data Source***	***Status***
Acute care days	Annual acute care patient days	0 - 414 Low and high utilization	Continuous and binary	Hospital Separations Files	Derived
Acute care cost	Annual acute care cost calculated using a cost per weighted case and applied to both AC and SDC	$0 - $315,103 Low and high utilization	Continuous and binary	Hospital Separations Files	Derived
General practitioner visits	Annual number of visits to a GP	0 – 187 Low and high utilization	Continuous and binary	MSP Payment Information Master Files	Derived
General practitioner costs	Annual cost of the visits to a GP	$0 – $5,602 Low and high utilization	Continuous and binary	MSP Payment Information Master Files	Derived
Specialist physician visits	Annual number of visits to a specialist	0 – 125 Low and high utilization	Continuous and binary	MSP Payment Information Master Files	Derived
Specialist physician costs	Annual cost of the visits to a specialist	$0 - $9,186 Low and high utilization	Continuous and binary	MSP Payment Information Master Files	Derived
Total physician costs	Annual cost of GP and specialist physician combined	$0 - $9,947 Low and high utilization	Continuous and binary	MSP Payment Information Master Files	Derived
Total annual cost	Annual cost of acute care, physician visits and diagnostic procedures	$0 - $318,516 Low and high utilization	Continuous and binary	Hospital Separations Files and MSP Payment Information Master Files	Derived

3.7 Analytic Methods

Analysis of the data related to a number of areas:

1. Description of the study population.
2. Development of summary adherence measures.
3. Description of adherence to recommended clinical procedures by the study population, including trends in adherence.
4. Description of the utilization of acute care and physician resources by the study population, including trends in utilization.
5. Univariate analysis of the relationship between study population characteristics and adherence to recommended clinical procedures.
6. Univariate analysis of the relationship between study population characteristics and utilization of physician, acute care and total costs.
7. Multivariate analysis of the relationship between study population characteristics and adherence to recommended clinical procedures.
8. Multivariate analysis of the relationship between study population characteristics and utilization of physician, acute care and total costs.

Frequency distributions ("descriptive statistics" "frequencies" in SPSS 14.0 for Windows Graduate Student Version, Release 14.0.0 dated September 5, 2005) were used in the descriptive analysis of the population.

As noted in Section 3.6.1, three summary adherence variables were created based on the receipt by each patient of two or more HbA1c tests each of the five years, at least one urinary microalbumin test each of the five years, at least one eye exam each of the five years, at least one lipid test every three years and at least four blood pressure measurements in each of the five

years. The three summary adherence variables include an adherence variable with continuous values from 0 to 23, an adherence variable with the categorical values of low, medium and high adherence and a binary adherence variable with the values of low or high adherence.

To determine the best clustering of these values into categorical (low, medium and high adherence) and binary variables (low or high adherence), we used the Jenks optimization algorithm (Environmental Systems Research Institute, Inc., ArcView GIS 3.3, 1992-2002). This method is based on an algorithm developed by Fisher (1958) and belongs to a class of clustering procedures designated as methods of partition by exact optimization (Hartigan, 1975). The Jenks method is used to create a grouping or partition of N objects into K non-intersecting subsets – P(N,K) – in such a way that an error function – e[P(N,K)] – is minimized. The method guarantees a partition with the smallest possible within-group variance for a given K value. For three non-intersecting subsets, the Jenks optimization algorithm indicated a clustering of scores from 0 to 9 (low adherence), 10 to 14 (medium adherence) and 15 to 23 (high adherence). For two non-intersecting subsets (for the binary variable), the recommended clustering was from 0 to 12 (low adherence) and 13 to 23 (high adherence).

In the description of adherence to recommended clinical procedures and utilization of physician, acute care and total costs by the study population we used proportions and means as appropriate, together with 95% confidence interval values. In calculating the 95% confidence interval of a proportion we used the method described by Newcombe (1998) derived from a procedure outlined by Wilson (1927). We applied the Wilson procedure without a correction for continuity. The actual calculations were done using the calculator developed by Lowry available online.[11]

[11] At www.faculty.vassar.edu/lowry/prop1.html

In calculating the 95% confidence interval of a mean we used the "explore function" under "descriptives" in SPSS 14.0. The algorithm used for this calculation is:

Lower bound = $\bar{y} - t_{\alpha/2,\ W-1}SE$

Upper bound = $\bar{y} + t_{\alpha/2,\ W-1}SE$

Where SE is the standard error and W is the total sum of weights.

To assess changes in proportions on a year over year basis, we used the McNemar test (McNemar, 1947). The McNemar test is a non-parametric test which assesses the significance of the difference between two dependent samples when the variable of interest is a dichotomy (i.e., whether or not a test or procedure was received). We applied the McNemar test in determining whether there was a significant change in the proportion of individuals with diagnosed diabetes receiving a specific test or procedures from year to year between 1996/97 and 2000/01.

Testing for trend in the proportion of adults with diagnosed diabetes receiving a specific test or procedure could be accomplished using Chi-square for trend if the key assumption of independence among the proportions was met. In this study, the annual proportions represent measures based on the same sample of adults with diagnosed diabetes throughout the five year period. Thus the assumption of independence is not met. To address this issue, Dr. Bob Prosser developed the algorithm in Appendix A specifically for this study. This SPSS algorithm produces bootstrap samples, computes proportions of 1s for five indicator variables and tests three trend components (linear, quadratic and cubic) for these proportions. The significance testing performed in the algorithm takes into account the dependence among the proportions.

The linear component of trend analysis is used to test if there is an overall increase or decrease in the dependent variable (e.g. proportion of adults with diagnosed diabetes who received X services) over the five years of the study. The quadratic component of trend analysis

is used to test whether the slope increases / decreases in the dependent variable. The cubic component of trend analysis is used to test whether the slope changes twice (decreasing and then increasing or increasing and then decreasing) in the dependent variable.

Binary logistic regression is used to estimate the probability that an event occurs when the dependent variable is a dichotomy and the independents are of any type. Four binary logistic regression models were constructed to test the relationship between the study population characteristics and adherence to recommended clinical procedures and utilization of physician, acute care and total costs. The first model examined the relationship between the independent variables (patient characteristics including gender, age, socio-economic status, location of residence, diabetes-specific severity and level of morbidity) and the likelihood of being in the low or high adherence group. The second, third and fourth models examined the relationship between the independent variables (patient characteristics including gender, age, socio-economic status, location of residence, diabetes-specific severity, level of morbidity and level of adherence) and the likelihood of being in the low or high average annual physician, acute care and total cost categories, respectively.

The general strategy used in constructing all four models was similar. The first step was a univariate analysis in order to explore the relationship between the covariates and the response variable and to estimate the strength and significance of any observed relationship. All independent variables were treated as categorical. For each combination of independent variable and covariate, univariate logistic regression models were created to estimate unadjusted regression coefficients and to examine for statistically significant associations.

The choice of a reference category (or ‘left-out’ group) is important as the beta coefficients for dummy variables will reflect changes in the dependent with respect to the

reference group. At least three considerations should be taken into account in choosing the reference group. The first is that the reference group is well defined; comparing to a miscellaneous reference group would not be appropriate. Second, the reference group should not be one with a small sample size as this could lead to unstable reference comparisons. Thirdly, it may be more appropriate to choose a 'middle' category rather than a group at either extreme as comparisons with median groups are usually easier to interpret than comparisons with extremes.

The choice of reference group for this study was based on a combination of sample size and middle categories. Middle categories were chosen when the sample size was sufficient and the middle category was meaningful (e.g. the middle age group of 50-59 was chosen; a socio-economic status of 3 was chosen; medium morbidity and a severity index of one or more intermediate complications was chosen). Patients were grouped into local health areas to reflect their place of residence. The LHA of Surrey was chosen as the reference sample because it was the LHA with the largest population size. Finally the male gender was randomly chosen as the reference category for gender.

Based on the results of the univariate analysis, the second step involved selecting variables for entry into the full multivariate model. Any variable for which the univariate test had a *p* value of less than 0.25 was considered a candidate for the multivariate model. The 0.25 level has been suggested as an appropriate level for selection of candidate variables for both linear (Bendel and Afifi, 1977) and logistic regression (Mickey and Greenland, 1989) models. These authors have demonstrated that the use of the more traditional level of 0.05 for variable selection often fails to identify important variables. In addition, any variable of known or hypothesized significance was assessed in the full model regardless of the significance results in the univariate analysis.

The independent variables were then incorporated into the Binary Logistic Regression function of SPSS based on the explanatory power of the variable. Once all of the variables were assimilated in the model, each variable was sequentially removed in reverse order to assess the impact of the exclusion of each variable from the full or main effects model.

After the development of the main effects model, all possible two-way interactions were tested individually based on Wald statistics and their *p*-values ($p<0.05$). To assess these potential interactions in the model, the main effects were entered as a block and the potential two-way interactions were included as a second block using the Forward Stepwise (Likelihood Ratio) approach. This approach identified any two-way interactions that remained significant ($p<0.05$) after adjusting for the other variables in the model.

Potential three-way interactions were then tested based on the Wald statistic and its *p*-value ($p<0.05$) for the variables found to be significant in the two-way interactions. To assess these potential interactions in the model, the main effects were entered as a block and the significant two-way interactions and any potential three-way interactions were included as a second block using the Forward Stepwise (Likelihood Ratio) approach. This approach identified any two- and three-way interactions that remained significant after adjusting for the other variables in the model. These significant two- and three-way interactions were included with the main effects to generate the final fitted model.

Nagelkerke's R-Square (Nagelkerke, 1991) was used in measuring the strength of association between the independent and dependent variables. This measure seeks to make a statement about the percent of the variance in the dependent variable explained by the independent variable(s). Nagelkerke's R-Square was used to measure the strength of association between each independent and the dependent variable in the univariate analyses and to assess the

strength of the association between the independent variables selected for the final fitted multivariate models and the appropriate dependent variable.

Hosmer and Lemeshow's (1989) goodness-of-fit test was used in assessing the final multivariate model for goodness-of-fit. This test divides subjects into deciles based on predicted probabilities, then computes a chi-square from observed and expected frequencies. Then a probability (p) value is computed from the chi-square distribution with eight degrees of freedom to test the fit of the logistic regression model. A *p*-value of greater than 0.05 indicates that the model's estimates fit the data at an acceptable level.

CHAPTER IV: RESULTS

4.1 Description of the Study Population

4.1.1 Overview of Study Population

As discussed in *Chapter 3*, a cohort of 20,228 adults with diagnosed type 2 diabetes was selected based on an algorithm of two or more physician service claims or one hospitalization with a diagnostic code of diabetes within the two year period from April 1, 1998 to March 31, 2001. The population of 20,228 excludes:

- those who moved in or out of the Fraser Health Authority geographic region during the five years from April 1, 1996 to March 31, 2001;
- incident cases;
- those who were under the age of 30 on April 1, 1998 (as a proxy for type 1 diabetes);
- those who died during the five year study period;
- those who had a serious illness (end stage renal disease, AIDS, high impact cancers) which likely would be the focus of care, potentially to the exclusion of adherence to the measures and services tracked in this study; and
- those 80 years of age and older.

The population of 20,228 represents a relatively stable cohort of adults with diagnosed type 2 diabetes for whom adherence to the measures and services tracked in this study could be expected to be appropriate.

Table 4-1 provides a summary of the population characteristics of this cohort over the five year period.

Table 4-1 Study Population Characteristics

	1996/97		1997/98		1998/99		1999/00		2000/01	
	#	%	#	%	#	%	#	%	#	%
Total Population	20,228		20,228		20,228		20,228		20,228	
By Sex										
Female	9,256	45.9%	9,256	45.9%	9,256	45.9%	9,256	45.9%	9,256	45.9%
Male	10,917	54.1%	10,917	54.1%	10,917	54.1%	10,917	54.1%	10,917	54.1%
By Age										
30-39	1,346	6.7%	1,197	5.9%	1,081	5.3%	914	4.6%	753	3.9%
40-49	3,389	16.9%	3,103	15.4%	2,795	13.8%	2,552	12.8%	2,306	11.8%
50-59	5,156	25.6%	5,122	25.4%	5,054	25.0%	4,881	24.5%	4,797	24.6%
60-69	6,358	31.6%	6,294	31.2%	6,205	30.7%	6,143	30.9%	5,991	30.7%
70-79	3,860	19.2%	4,448	22.1%	5,093	25.2%	5,422	27.2%	5,671	29.1%
By Socio-Economic Status										
Quintile 1 (Low)	3,998	21.3%	4,034	20.6%	4,026	20.3%	4,196	21.4%	4,221	21.5%
Quintile 2	4,215	22.5%	4,292	21.9%	4,330	21.8%	4,445	22.7%	4,421	22.5%
Quintile 3	4,380	23.4%	4,586	23.4%	4,638	23.4%	4,341	22.1%	4,350	22.1%
Quintile 4	3,709	19.8%	4,044	20.6%	4,121	20.8%	4,045	20.6%	4,090	20.8%
Quintile 5 (High)	2,433	13.0%	2,649	13.5%	2,706	13.7%	2,593	13.2%	2,573	13.1%
By Morbidity										
Very Low	334	1.7%	334	1.7%	334	1.7%	334	1.7%	334	1.7%
Low	2,186	10.9%	2,186	10.9%	2,186	10.9%	2,186	10.9%	2,186	10.9%
Medium	4,500	22.4%	4,500	22.4%	4,500	22.4%	4,500	22.4%	4,500	22.4%
High	7,449	37.1%	7,449	37.1%	7,449	37.1%	7,449	37.1%	7,449	37.1%
Very High	5,622	28.0%	5,622	28.0%	5,622	28.0%	5,622	28.0%	5,622	28.0%
By Disease-Specific Severity Index										
No Complications	6,366	31.5%	6,366	31.5%	6,366	31.5%	6,366	31.5%	6,366	31.5%
1 or More Minor Complications	6,951	34.4%	6,951	34.4%	6,951	34.4%	6,951	34.4%	6,951	34.4%
1 or More Intermediate Complications	6,289	31.1%	6,289	31.1%	6,289	31.1%	6,289	31.1%	6,289	31.1%
1 Major Complication	338	1.7%	338	1.7%	338	1.7%	338	1.7%	338	1.7%
2 or More Major Complications	284	1.4%	284	1.4%	284	1.4%	284	1.4%	284	1.4%
By Patient Residence										
LHA 202 - S. Surrey / WR	1,028	5.1%	1,025	5.1%	1,035	5.1%	1,046	5.2%	1,043	5.2%
LHA 201 - Surrey	4,820	23.8%	4,845	24.0%	4,861	24.0%	4,882	24.1%	4,874	24.1%
LHA 076 - Agassiz-Harrison	123	0.6%	123	0.6%	123	0.6%	125	0.6%	127	0.6%
LHA 075 - Mission	558	2.8%	557	2.8%	560	2.8%	555	2.7%	562	2.8%
LHA 043 - Coquitlam	2,456	12.1%	2,437	12.0%	2,434	12.0%	2,434	12.0%	2,408	11.9%
LHA 042 - Maple Ridge	1,037	5.1%	1,054	5.2%	1,056	5.2%	1,069	5.3%	1,085	5.4%
LHA 041 - Burnaby	3,365	16.6%	3,287	16.2%	3,253	16.1%	3,206	15.8%	3,184	15.7%
LHA 040 - New Westminster	903	4.5%	911	4.5%	903	4.5%	908	4.5%	915	4.5%
LHA 037 - Delta	1,442	7.1%	1,420	7.0%	1,404	6.9%	1,380	6.8%	1,369	6.8%
LHA 035 - Langley	1,549	7.7%	1,574	7.8%	1,564	7.7%	1,556	7.7%	1,573	7.8%
LHA 034 - Abbotsford	1,781	8.8%	1,811	9.0%	1,837	9.1%	1,854	9.2%	1,861	9.2%
LHA 033 - Chilliwack	1,038	5.1%	1,052	5.2%	1,065	5.3%	1,080	5.3%	1,090	5.4%
LHA 032 - Hope	130	0.6%	132	0.7%	133	0.7%	133	0.7%	137	0.7%

In the median year (fiscal 1998/99), 46% of the population was female. The majority (56%) of individuals were between the ages of 50 and 69. Few individuals were in the very low morbidity group (1.7%) with the majority being in either the high or very high morbidity groups (65.1%). One hundred and thirty seven individuals were in the 'pregnancy' ACG. Based on the disease-specific severity information, a substantial number of individuals (32%) were assessed as having no diabetes specific complicating conditions (as defined in section 3.6.2 Patient

Characteristics) while few individuals had one or more major diabetes specific complicating conditions (3%). The local health area with the largest contingent of patients was Surrey (24%) followed by Burnaby (16%) and Coquitlam (12%).

There were no missing variables for age, local health area, general morbidity or disease-specific severity index. While information on age was available for the entire cohort, information on gender was missing for 55 (0.27%) individuals. Information on socio-economic status was missing for 1,493 (7.38%) individuals in 1996/97, 623 (3.08%) individuals in 1997/98, 407 (2.01%) individuals in 1998/99, 608 (3.00%) individuals in 1999/00 and 574 (2.84%) individuals in 2000/01.

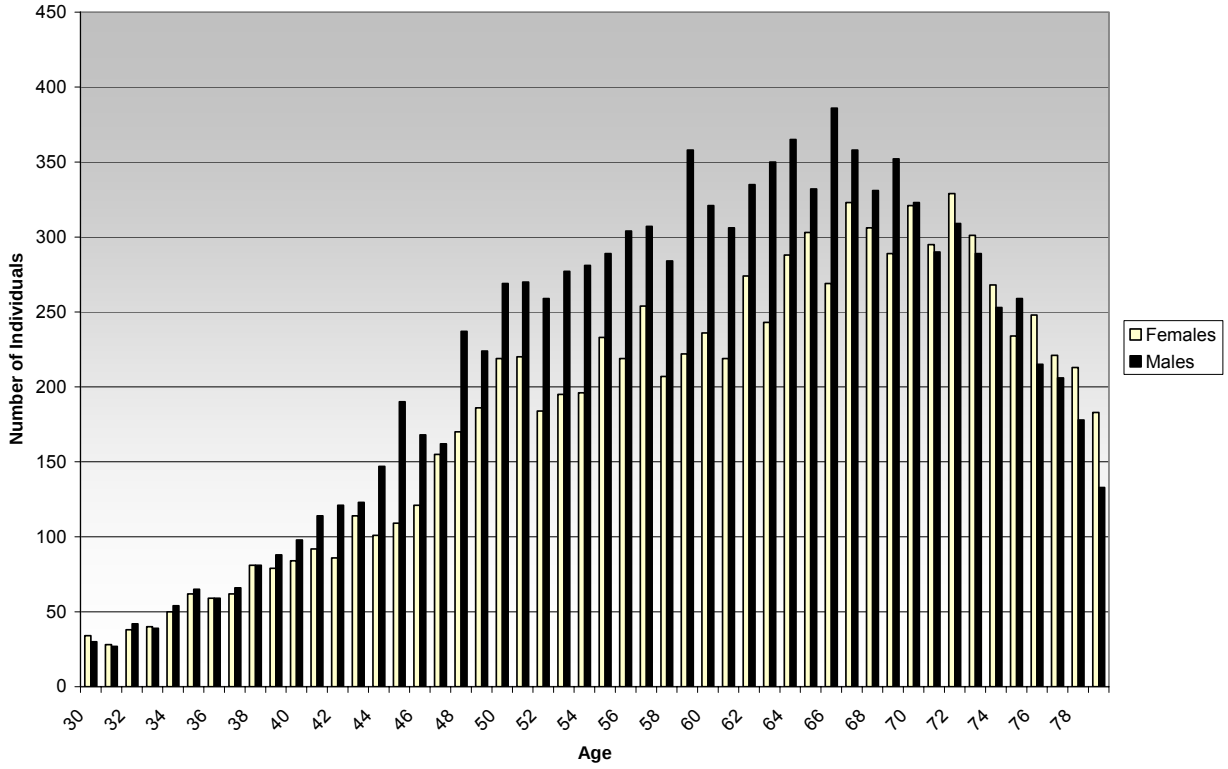
4.1.2 Age and Gender

The mean age for the entire population is 60.3 years (SD 11.5), 60.8 years for females (SD 11.8) and 59.8 years for males (SD 11.3). The median age for the entire population is 62 years with an interquartile range (IQR) of 18, 63 years (IQR of 18) for females and 61 years (IQR of 17) for males. Information on the frequency distribution by age (on April 1, 1998) and gender is provided on Table 4-2 and Figure 4-1.

Table 4-2 Frequency Distribution
For Age (April 1, 1998) and Gender

Age	Female	Male	Unknown	Total	% Frequency	Cumulative Frequency	Cumulative % Frequency
30	34	30	-	64	0.17%	64	0.32%
31	28	27	-	55	0.14%	119	0.59%
32	38	41	-	79	0.19%	198	0.98%
33	40	39	-	79	0.20%	277	1.37%
34	49	54	-	103	0.24%	380	1.88%
35	62	65	-	127	0.31%	507	2.51%
36	59	59	-	118	0.29%	625	3.09%
37	62	66	-	128	0.31%	753	3.72%
38	80	81	-	161	0.40%	914	4.52%
39	79	88	-	167	0.39%	1,081	5.34%
40	84	96	-	180	0.42%	1,261	6.23%
41	91	113	-	204	0.45%	1,465	7.24%
42	85	121	-	206	0.42%	1,671	8.26%
43	114	123	-	237	0.56%	1,908	9.43%
44	101	147	-	248	0.50%	2,156	10.66%
45	109	190	-	299	0.54%	2,455	12.14%
46	121	166	-	287	0.60%	2,742	13.56%
47	155	162	-	317	0.77%	3,059	15.12%
48	170	237	-	407	0.84%	3,466	17.13%
49	186	224	-	410	0.92%	3,876	19.16%
50	219	269	-	488	1.08%	4,364	21.57%
51	220	270	-	490	1.09%	4,854	24.00%
52	184	259	-	443	0.91%	5,297	26.19%
53	195	277	-	472	0.96%	5,769	28.52%
54	196	281	-	477	0.97%	6,246	30.88%
55	232	289	2	523	1.15%	6,769	33.46%
56	219	304	3	526	1.08%	7,295	36.06%
57	253	307	1	561	1.25%	7,856	38.84%
58	207	284	-	491	1.02%	8,347	41.26%
59	222	358	3	583	1.10%	8,930	44.15%
60	236	320	-	556	1.17%	9,486	46.90%
61	218	306	-	524	1.08%	10,010	49.49%
62	274	335	2	611	1.35%	10,621	52.51%
63	243	350	3	596	1.20%	11,217	55.45%
64	288	365	1	654	1.42%	11,871	58.69%
65	303	332	2	637	1.50%	12,508	61.84%
66	269	386	1	656	1.33%	13,164	65.08%
67	323	358	2	683	1.60%	13,847	68.45%
68	306	331	6	643	1.51%	14,490	71.63%
69	289	352	4	645	1.43%	15,135	74.82%
70	321	323	1	645	1.59%	15,780	78.01%
71	295	290	3	588	1.46%	16,368	80.92%
72	329	309	-	638	1.63%	17,006	84.07%
73	301	289	2	592	1.49%	17,598	87.00%
74	268	253	2	523	1.32%	18,121	89.58%
75	234	259	4	497	1.16%	18,618	92.04%
76	248	215	5	468	1.23%	19,086	94.35%
77	221	206	5	432	1.09%	19,518	96.49%
78	213	178	3	394	1.05%	19,912	98.44%
79	183	133	-	316	0.90%	20,228	100.00%
Total	**9,256**	**10,917**	**55**	**20,228**	**100.00%**		

Figure 4-1 Frequency Distribution
By Age (April 1, 1998) and Gender



4.1.3 Prevalence and Incidence Rates

How does the population of adults with diagnosed type 1 and 2 diagnosis living in the geographic boundaries of the Fraser Health Authority compare to other published results on the prevalence of diagnosed diabetes?

The calculation of prevalence from this study population is based on the initial draw of 64,020 individuals less MSP exclusions (n=168), diagnostic rule-outs (n=18,054), children (n=800), and gestational diabetes (n=1,106) for a total of 43,998 individuals (see section 3.5.12 Summary). In addition, 141 of those who were under the age of 20 on April 1, 1996 were 20 or 21 by April 1, 1998. In total, there were 44,033 adults with diagnosed type 1 or 2 diabetes identified as of April 1, 1998. Patients with type 1 diabetes are included in the calculation of

prevalence and incidence rates for comparability with rates in other jurisdictions. As noted earlier, the identification of individuals with type 1 diabetes using administrative data is difficult and thus combined rates are usually calculated for type 1 and 2 diabetes.

The calculated prevalence per 100 population by age and gender is indicated on table 4-3. Furthermore, this prevalence is compared to the prevalence from Ontario for that same year (1998) as identified by Hux and Tang (2003).

Table 4-3 People with Diagnosed Diabetes

Fraser Health - 1998

Age Group

	20-34	35-49	50-64	65-74	75+	Total
Females	1,310	3,343	6,338	5,083	4,126	**20,200**
Males	1,011	4,498	8,773	5,845	3,588	**23,715**
Unknown		1	19	37	61	**118**
Total	**2,321**	**7,842**	**15,130**	**10,965**	**7,775**	**44,033**

Population

	20-34	35-49	50-64	65-74	75+	Total
Females	142,722	161,847	93,667	47,053	42,876	**488,165**
Males	147,220	165,673	95,484	39,502	25,294	**473,173**
Total	**289,942**	**327,520**	**189,151**	**86,555**	**68,170**	**961,338**

Prevalence (Rate per 100 Population)

	20-34	35-49	50-64	65-74	75+	Total
Females	0.92	2.07	6.77	10.80	9.62	**4.14**
Males	0.69	2.71	9.19	14.80	14.19	**5.01**
Total	**0.80**	**2.39**	**8.00**	**12.67**	**11.41**	**4.58**

Prevalence in Ontario - 1998

Rate per 100 Population

	20-34	35-49	50-64	65-74	75+	Total
Females	0.96	2.77	8.04	13.89	15.17	
Males	0.74	3.28	10.99	17.74	18.98	
Total						**5.82**

The prevalence for this study population and those for Ontario as a whole are very similar for the 20-34 year age group for both males and females. The rates for the older cohorts, however, are consistently higher for the Ontario population than this study population. For all adults with diagnosed type 1 and 2 diabetes living within the geographic boundaries of the Fraser Health Authority, the prevalence rate per 100 in 1998 was 4.58 compared to 5.82 for Ontario.

These summary rates are not directly comparable as they have not been adjusted for differences in the age and gender structure of the two populations in 1998.

The incidence rate for the current study population is based on the 12,569 identified incident cases (Table 4-4). Furthermore, this incidence rate is compared to the incidence rate from Ontario for that same year (1998) as identified by Hux and Tang (2003).

Table 4-4 People with Newly Diagnosed Diabetes
Fraser Health and Ontario - 1998

Age Group

	20-34	35-49	50-64	65-74	75+	Total
Females	620	1,222	1,808	1,162	932	**5,744**
Males	380	1,704	2,540	1,385	787	**6,796**
Unknown	-	1	4	9	15	**29**
Total	**1,000**	**2,927**	**4,352**	**2,556**	**1,734**	**12,569**

Population

	20-34	35-49	50-64	65-74	75+	Total
Females	142,722	161,847	93,667	47,053	42,876	**488,165**
Males	147,220	165,673	95,484	39,502	25,294	**473,173**
Total	**289,942**	**327,520**	**189,151**	**86,555**	**68,170**	**961,338**

Incidence (Rate per 100 Population)

	20-34	35-49	50-64	65-74	75+	Total
Females	0.43	0.76	1.93	2.47	2.17	**1.18**
Males	0.26	1.03	2.66	3.51	3.11	**1.44**
Total	**0.34**	**0.89**	**2.30**	**2.95**	**2.54**	**1.31**

Incidence in Ontario - 1998
Rate per 100 Population

	20-34	35-49	50-64	65-74	75+	Total
Females	0.17	0.41	0.99	1.32	1.28	
Males	0.12	0.51	1.30	1.66	1.56	
Total						**0.66**

Unlike the comparison of prevalence between the study sample and the Ontario population, the incidence rates by age and gender for the study sample are consistently higher (almost 2-fold) than the Ontario incidence rates. This is likely due to the fact that we used a two-year wash-out period. In other words, the data from the two years prior to April 1, 1998 was examined in order to discover newly diagnosed cases during the period of interest, which ran from April 1/96 to March 31, 1998 (i.e. no ICD9-250 codes during this two year period). The

Ontario study used a three-year wash-out period. With a longer wash-out period, fewer cases would be identified as newly diagnosed rather than existing cases.

4.1.4 False Negative Results in Diagnostic Rule-outs

As noted earlier, Hux and colleagues (2002) in Ontario have tested two algorithms for assessing the prevalence of diabetes using an administrative data base, including one which required only one physician service claim. They found that using only a single physician service claim resulted in an unacceptable level of false positive identifications, possibly due to cases where diabetes was suspected but subsequent laboratory tests did not confirm this suspicion. In this study, we have called patients with only one MSP ICD9-250 claim during the two year period from April 1, 1998 to March 31, 2000 diagnostic rule-outs. As identified in section 3.5.3. Diagnostic Rule-Outs, this is a significant group of patients (18,054 in this study).

While the issue of false positive identifications using the one physician service code algorithm is an important one, is the issue of false negatives also significant? That is, are there a group of patients whom we have identified as diagnostic rule-outs that might indeed be individuals with diagnosed diabetes? To address this question, we examined the use of the ICD9-250 code for each of these 18,054 patients during the two-year period from April 1, 1996 to March 31, 1998. The results are indicated on table 4-5.

Table 4-5 Diagnostic Rule-Outs
False Negatives

Percent	Number	ICD9-250 Codes During April 1, 1996 to March 31, 1998
85.68%	15,469	No 250 Codes
11.23%	2,027	No Hospital But At Least Two MSP 250 Codes
2.02%	364	At Least One Hospital and Two or More MSP 250 Codes
0.63%	113	At Least One Hospital But No MSP 250 Codes
0.45%	81	At Least One Hospital and One MSP 250 Code
100.00%	**18,054**	**Total**

Based on the use of the ICD9-250 code during April 1, 1996 to March 31, 1998 in either the physician or hospitalization data, 2,585 of the 18,054 diagnostic rule-outs (or 14.3%) would be identified as having diagnosed type 1 or 2 diabetes. That is, if the time frame used to identify individuals with diagnosed type 1 or 2 diabetes in this study population were expanded from a two-year period (April 1, 1998 to March 31, 2000) to a four-year period (April 1, 1996 to March 31, 2000), then we would have identified an additional 2,585 of the initial study population as having diagnosed diabetes as opposed to including these patients in the diagnostic rule-out group.

4.1.5 Comparison of the Generic Morbidity and Disease-Specific Severity Indices

As noted in section 3.6.2 Patient Characteristics, two measures of morbidity were utilized in this study. The first is a generic morbidity index used by Broemeling et al. (2005) in British Columbia while the second is a disease-specific severity index developed by Reid (1998). These two indices measure different concepts in that the general measure of morbidity provides a gauge of the level of co-morbidities experienced by the patient over time, regardless of whether these co-morbidities are directly associated with the patient's diabetes while the diabetes-specific disease severity index provides a measure of the level and severity of diabetes-specific complicating conditions that influence diabetes management. The following comparison clearly indicates this difference.

Table 4-6 presents information on the diabetes disease-specific severity index for the population as a whole and by age group. On the whole, diabetes related complicating conditions were fairly common, with 13,862 (69%) of the population having at least one such diagnosis. The majority of patients had relatively minor complicating conditions as only 622 (3.1%) patients were assigned diabetes related codes relating to a major complicating condition. This

low proportion may at least be partially due to the exclusion of individuals with high impact diseases from the final study population. Included in this exclusion group of high impact diseases, for example, were 282 individuals with diagnosed end stage renal disease. Renal disease is one of the major complicating conditions identified in the diabetes disease-specific severity index.

Table 4-6 Disease Specific Severity Index
By Age Group

	Age Group					
DSS Index	30-39	40-49	50-59	60-69	70-79	**Total**
No Complications	645	1,335	1,817	1,573	996	**6,366**
1 or More Minor	233	904	1,920	2,319	1,575	**6,951**
1 or More Intermediate	139	478	1,182	2,135	2,355	**6,289**
1 Major	32	38	65	100	103	**338**
2 or More Major	32	40	70	78	64	**284**
Total	**1,081**	**2,795**	**5,054**	**6,205**	**5,093**	**20,228**

	Age Group					
DSS Index	30-39	40-49	50-59	60-69	70-79	
No Complications	60%	48%	36%	25%	20%	31%
1 or More Minor	22%	32%	38%	37%	31%	34%
1 or More Intermediate	13%	17%	23%	34%	46%	31%
1 Major	3%	1%	1%	2%	2%	2%
2 or More Major	3%	1%	1%	1%	1%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

A total of 31% (6,366) of individuals had no diabetes-related complicating conditions. This proportion is substantially different when the age of the individual is taken into account. Fully 60% of individuals aged 30-39 had no diabetes-related complicating conditions compared to just 20% of those aged 70-79.

The majority of the study population had one or more minor or intermediate complicating conditions (65% or 13,240). The proportion of the population with one or more minor or

intermediate complicating conditions also increased with age. Only 35% of the study population aged 30-39 fit within this category compared to 76% of those aged 70-79.

Information based on the generic morbidity index used in this study is presented in table 4-7 for the population as a whole and by age group. On the whole, 2% (334) of the study population were in the very low morbidity category, 11% (2,286) in the low category, 22% (4,500) in the medium category, 37% (7,449) in the high category and 28% (5,622) in the very high category.

Table 4-7 Generic Morbidity Index (ACG)
By Age Group

	Age Group					
ACG	30-39	40-49	50-59	60-69	70-79	**Total**
Very Low	16	58	109	100	51	**334**
Low	118	371	646	669	382	**2,186**
Medium	264	729	1,256	1,350	901	**4,500**
High	344	965	1,804	2,339	1,997	**7,449**
Very High	243	654	1,219	1,744	1,762	**5,622**
Pregnancy	96	18	20	3	-	**137**
Total	**1,081**	**2,795**	**5,054**	**6,205**	**5,093**	**20,228**

	Age Group					
ACG	30-39	40-49	50-59	60-69	70-79	
Very Low	1%	2%	2%	2%	1%	2%
Low	11%	13%	13%	11%	8%	11%
Medium	24%	26%	25%	22%	18%	22%
High	32%	35%	36%	38%	39%	37%
Very High	22%	23%	24%	28%	35%	28%
Pregnancy	9%	1%	0%	0%	0%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The fact that 65% of the study population was in the top two morbidity groups is significantly different than the findings by Broemeling et al. (2005) who studied data from the entire province of British Columbia. In the current study, we followed the methodology of

Broemeling et al. (2005) in assigning individuals with an index condition of diabetes to five groups based on their co-morbidity level. The presence of co-morbidities was identified using ACGs (see Section 3.6.2 Patient Characteristics). A comparison of the proportion of adults with diagnosed diabetes in each of the five morbidity categories between the two studies is indicated below.

- Level 1 – No co-morbidity (just diabetes) – 9% in Broemeling vs. 1.7% in current study
- Level 2 – Low co-morbidity (2 or 3 types of conditions) – 29% vs. 10.9%
- Level 3 – Medium co-morbidity (4 or 5 types of conditions) – 30% vs. 22.4%
- Level 4 – High co-morbidity (6 to 9 types of conditions) – 25% vs. 37.1%
- Level 5 – Very high co-morbidity (10+ types of conditions) – 7% vs. 28.0%

One likely explanation for this difference is the exclusion of incident cases (N=12,569) from the current study population. Incident cases are more likely to be in the lower rather than the higher co-morbidity groups. In addition, individuals under the age of 30 were excluded from the study sample to reduce the possibility of including patients with type 1 diabetes. As with incident cases, however, these excluded younger patients are more likely to be in the lower rather than the higher co-morbidity groups. In the 30-39 year age group, for example, only 54% of the population was in the high or very high co-morbidity category compared with 74% of those aged 70-79.

A comparison of the results of the disease-specific severity index and the generic morbidity index is provided in table 4-8.

Table 4-8 Comparison of Generic Morbidity Index (ACG) and Disease-specific Severity Index

ACG	Disease-Specific Severity Index: Presence of Complications — None	1 or More Minor	1 or More Intermediate	One Major	2 or More Major	Total
Very Low	208	121	5	-	-	**334**
Low	1,174	786	221	2	3	**2,186**
Medium	1,910	1,727	828	24	11	**4,500**
High	2,113	2,586	2,551	125	74	**7,449**
Very High	878	1,703	2,661	184	196	**5,622**
Pregnancy	83	28	23	3	-	**137**
Total	**6,366**	**6,951**	**6,289**	**338**	**284**	**20,228**

ACG	Disease-Specific Severity Index: Presence of Complications — None	1 or More Minor	1 or More Intermediate	One Major	2 or More Major
Very Low	3%	2%	0%	0%	0%
Low	18%	11%	4%	1%	1%
Medium	30%	25%	13%	7%	4%
High	33%	37%	41%	37%	26%
Very High	14%	25%	42%	54%	69%
Pregnancy	1%	0%	0%	1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

What is particularly noticeable in this comparison is the fact that 47% (2,991 of 6,366) of patients who had no diabetes-related complications were assigned to the high or very high generic morbidity category. This suggests that these individuals had a constellation of at least six co-morbidities unrelated to the specific complicating conditions identified by the disease-specific severity index.

4.2 Description of Individual Adherence Variables

4.2.1 Overview

A key aim of this study was to determine whether adherence to a series of recommended tests and procedures for adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority had changed during the five years from April 1, 1996 to March 31, 2001. Adherence was measured based on the receipt of the following recommended services:

- Two or more HbA1c tests during each fiscal year
- At least one retinal eye exam during each fiscal year
- At least one urinary microalbumin test during each fiscal year
- At least one serum lipid test every three years
- At least four blood pressure measurements each year. The proxy measure for this is whether or not at least four visits to a general practitioner had taken place during each fiscal year.

In addition, the overall receipt of recommended services was assessed for each individual on an annual basis to determine how many of the five recommended services they received. Individuals at either extreme (either they received all or none of the five recommended services) were identified.

A summary of all seven measures noted above is provided in table 4-9. A significant change was observed between 1996/97 and 2000/01 for all seven measures. As noted in Appendix C, however, there is considerable variability in the year by year changes. Figures 4-2 and 4-3 provide these same results in a graphic format.

Table 4-9 Proportion of Adults with Diagnosed Type 2 Diabetes Receiving the Following Recommended Services

	Fiscal Year					Test for Trend *Linear*			*Quadratic*			*Cubic*		
	1996/97	1997/98	1998/99	1999/00	2000/01	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Two or More HbA1C Tests During the Year	34.8%	43.3%	45.9%	49.6%	51.7%	0.403	0.383	0.423	-0.117	-0.138	-0.096	0.043	0.025	0.062
At Least One Retinal Eye Exam During the Year	35.9%	40.2%	39.9%	40.8%	39.4%	0.076	0.059	0.095	-0.103	-0.122	-0.083	0.023	0.003	0.041
At least One Microalbumin Test During the Year	13.2%	20.4%	25.8%	34.1%	37.6%	0.626	0.609	0.643	-0.043	-0.062	-0.025	-0.032	-0.048	-0.015
At Least One Lipid Test Every Three Years		77.1%												
			80.4%											
				82.2%										
At least Four Blood Pressure Measurements During the Year	80.5%	84.6%	84.3%	86.1%	85.4%	0.112	0.097	0.128	-0.074	-0.090	-0.059	0.020	0.007	0.032
Received all Services	3.9%	6.1%	7.0%	9.9%	10.7%	0.175	0.163	0.186	-0.007	-0.019	0.006	-0.009	-0.020	0.002
Received None of the Services	3.0%	1.8%	1.7%	1.8%	2.2%	-0.017	-0.024	-0.010	0.034	0.027	0.040	-0.008	-0.014	-0.003

Note: N=20,228

Figure 4-2 Proportion of Adults with Diagnosed Type 2 Diabetes Who Received Recommended Services

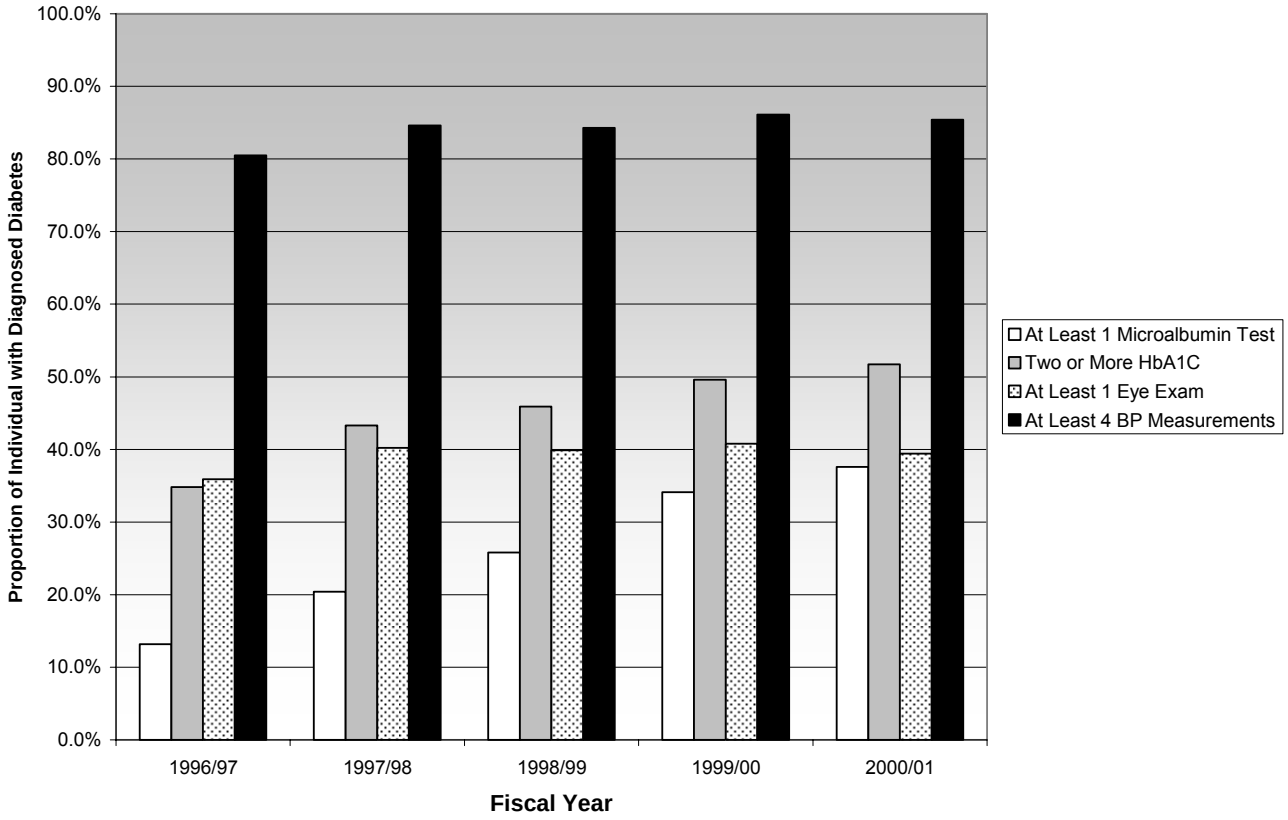
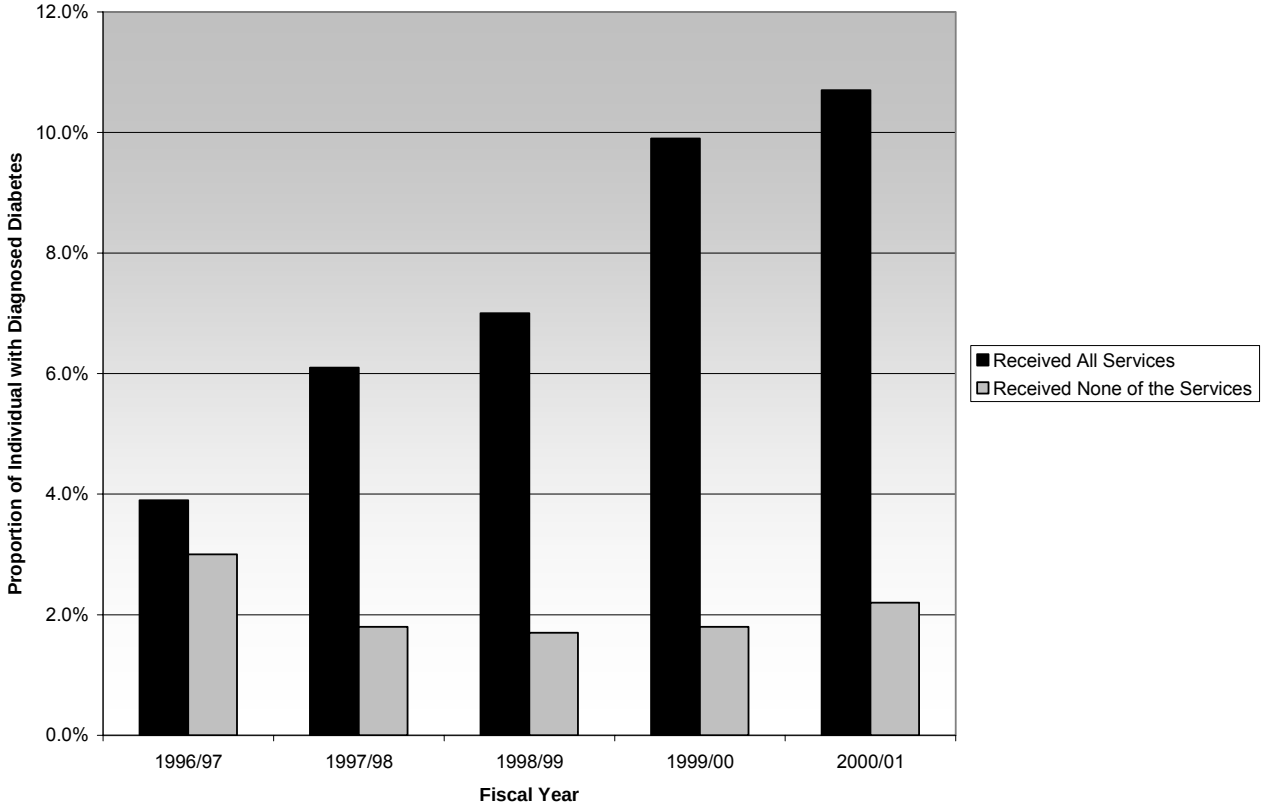


Figure 4-3 Proportion of Adults with Diagnosed Type 2 Diabetes
Who Received Recommended Services



Are all (or most) of the eye exams being captured through the Medical Service Plan (MSP) data available through the BC Linked Health Data Set? Routine eye exams were delisted from MSP coverage effective November 19, 2001, part way through the 2001/02 fiscal year, i.e. after the end of the current study period. Even with the delisting of routine eye exams, eye exams for patients with diabetes are still covered through MSP. The following is a quote from the November 27, 2001 *MSCommunique*. "A routine (their emphasis) eye examination is not a benefit for individuals 19-64 when not associated with an ocular or systemic disease or condition….An eye examination will still be an insured service if medically required. Medically

required eye examination may include the following:….Systemic disease associated with significant ocular risk (e.g. diabetes)…."[12]

The MSP fee codes used in capturing eye exams for this study are grouped in table 4-10 by the physician group who provided the eye exam. In 2000/01, 28% of eye exams were provided by ophthalmologists while 72% were provided by optometrists. The "other" group of providers consists of general practitioners (122 exams in 2000/01) and out-of-province providers (220 exams in 2000/01).

Table 4-10 Eye Exams by Physician Specialty And Fiscal Year

MSP Fee Item	1996/97	1997/98	1998/99	1999/00	2000/01
Ophthalmologist					
2010 - Consultation-Ophthalmology	190,076	201,825	198,143	210,837	211,108
2015 - Eye Examination	150,260	149,706	139,760	134,267	121,016
2039 - Fundus Photography	13,114	13,821	13,230	14,057	15,191
2040 - Retinoscopy Under General Anaesthetic	256	214	197	254	269
2898 - Reexamination or minor exam	-	-	-	-	-
2899 - Full Optometric Diagnostic	-	-	-	-	-
Subtotal	**353,706**	**365,566**	**351,330**	**359,415**	**347,584**
Optometrist					
2010 - Consultation-Ophthalmology	-	-	-	-	-
2015 - Eye Examination	-	-	-	-	-
2039 - Fundus Photography	-	-	-	-	-
2040 - Retinoscopy Under General Anaesthetic	-	-	-	-	-
2898 - Reexamination or minor exam	96,722	87,284	94,937	103,713	110,651
2899 - Full Optometric Diagnostic	759,333	680,772	707,558	766,286	786,958
Subtotal	**856,055**	**768,056**	**802,495**	**869,999**	**897,609**
Other					
2010 - Consultation-Ophthalmology	66	74	66	69	81
2015 - Eye Examination	1,938	1,976	1,995	1,409	57
2039 - Fundus Photography	17	8	11	6	134
2040 - Retinoscopy Under General Anaesthetic	-	-	-	1	-
2898 - Reexamination or minor exam	-	-	1	1	-
2899 - Full Optometric Diagnostic	29	51	49	54	70
Subtotal	**2,050**	**2,109**	**2,122**	**1,540**	**342**
Total	**1,211,811**	**1,135,731**	**1,155,947**	**1,230,954**	**1,245,535**

No specific fee code exists in MSP for a dilated retinal eye exam. It is possible, therefore, that the broader approach used in this study to track this recommended procedure may overestimate the proportion of adults with diagnosed type 2 diabetes who received a retinal eye exam. Routine eye exams were only delisted from MSP coverage after the end of the current

[12] See http://www.healthservices.gov.bc.ca/msp/legislation/communiques/2001.html (accessed March 2006)

study period. Even after they were delisted, however, routine eye exams for people with diabetes were still explicitly covered by MSP. As such, it is probable that the vast majority of eye exams are being captured through MSP, and thus are included in the data source used for this study.

4.2.2 Trend Analysis

As noted in Section 3.7 Analytic Methods the annual proportions represent measures based on the same sample of adults with diagnosed type 2 diabetes throughout the five year period. As such, the assumption of independence required for a Chi-square for trend test is not met. To address this issue, Dr. Bob Prosser developed an SPSS algorithm (see Appendix B) which produces bootstrap samples, computes proportions of 1s for five indicator variables and tests three trend components (linear, quadratic and cubic) for these proportions. The significance testing performed in the algorithm takes into account the dependence among the proportions.

The linear component of trend analysis is used to test if there is an overall increase or decrease in the dependent variable (e.g. proportion of adults with diagnosed diabetes who received X services) over the five years of the study. The quadratic component of trend analysis is used to test whether the slope increases or decreases in the dependent variable. The cubic component of trend analysis is used to test whether the slope changes twice (decreasing and then increasing or increasing and then decreasing) in the dependent variable. The results of testing for the statistical significance for trend are provided in table 4-9 above.

The mean value of the linear component for the target services is as follows:

- Two or more HbA1c tests per year - 0.40 (95% CI of 0.38 to 0.42)
- At least one eye exam per year - 0.08 (95% CI of 0.06 to 0.10)
- At least one urinary microalbumin test per year - 0.63 (95% CI of 0.61 to 0.64)
- At least four BP measurements per year - 0.11 (95% CI of 0.10 to 0.13)

Since the 95% confidence interval does not contain 0 for either of these measures, this indicates that there is a significant positive linear trend over the five years for each measure. Since neither of the quadratic or cubic 95% CIs contains 0 for any of these measures, this indicates that there is also a significant non-linearity to the trend for each individual measure. Thus, it is safe to say that there was improvement in each measure, although the degree of improvement was not predictable from year to year.

Similarly, the mean value of the linear component for receiving all five services per year is about 0.18 (95% CI of 0.16 to 0.19). Since the 95% CI does not contain 0, this indicates that there is a significant positive linear trend over the five years for the proportion of adults with diagnosed type 2 diabetes who received all five services per year. Both the quadratic and cubic 95% CIs contain 0, indicating that this is a linear trend. Therefore, the improvement in the proportion of patients receiving all five procedures was consistent and the degree of improvement could be predicted from year to year.

The mean value of the linear component for receiving none of the five services per year is about -0.017 (95% CI of -0.024 to -0.010). Since the 95% CI does not contain 0, this indicates that there is a significant *negative* linear trend. Since neither of the quadratic or cubic 95% CIs contains 0, this indicates that there is also a significant non-linearity to the trend. Indeed, as noted in Appendix C, this is one variable in which a significant increase was observed between 1999/00 and 2000/01 compared to a significant decrease between 1996/97 and 1997/98. In other words, the favourable drop in the number of individuals with diabetes receiving no service was not sustained, but began creeping up again.

4.3 Description of Summary Adherence Variables

4.3.1 Adherence as a Continuous Variable

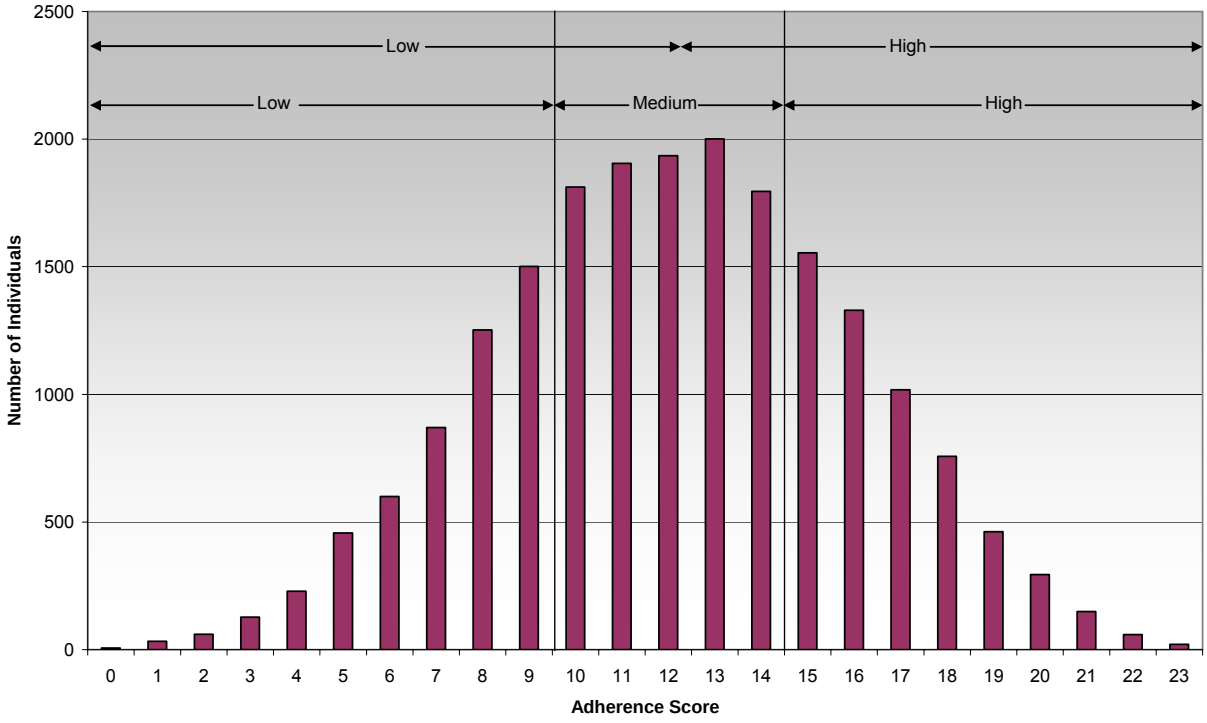
The frequency distribution for adherence scores is as follows:

Table 4-11 Frequency Distribution For Adherence Scores

Adherence Level	Frequency	% Frequency	Cumulative Frequency	Cumulative % Frequency
0	6	0.03%	6	0.03%
1	33	0.16%	39	0.19%
2	60	0.30%	99	0.49%
3	127	0.63%	226	1.12%
4	229	1.13%	455	2.25%
5	457	2.26%	912	4.51%
6	600	2.97%	1,512	7.47%
7	870	4.30%	2,382	11.78%
8	1253	6.19%	3,635	17.97%
9	1501	7.42%	5,136	25.39%
10	1812	8.96%	6,948	34.35%
11	1905	9.42%	8,853	43.77%
12	1935	9.57%	10,788	53.33%
13	2001	9.89%	12,789	63.22%
14	1795	8.87%	14,584	72.10%
15	1554	7.68%	16,138	79.78%
16	1330	6.58%	17,468	86.36%
17	1018	5.03%	18,486	91.39%
18	757	3.74%	19,243	95.13%
19	462	2.28%	19,705	97.41%
20	294	1.45%	19,999	98.87%
21	149	0.74%	20,148	99.60%
22	59	0.29%	20,207	99.90%
23	21	0.10%	20,228	100.00%
Total	**20,228**	**100.00%**		

This same information is provided in graphical format on figure 4-4.

Figure 4-4 Frequency Distribution for Adherence Scores



Descriptive information on adherence as a continuous variable is provided in table 4-12. The overall mean score for the population of 20,228 was 12.14 (standard deviation of 3.87; median of 12). Only 6 patients received a score of 0 and 21 received a score of 23. These two scores represent the extremes of potential adherence.

Based on the mean adherence scores as presented in table 4-12, higher mean adherence scores in the study sample are observed in females, who scored 12.37 compared to males, who scored 11.94. In addition, overall mean adherence scores tend to increase with age (10.66 for 30-39 year olds to 12.88 for 60-69 year olds) and higher levels of morbidity (9.65 for very low morbidity to 13.07 for very high morbidity). There appears to be a marginal increase in the mean adherence score when comparing individuals with a higher socio-economic status (quintiles 4 or

5) to individuals with a low socio-economic status (quintile 1). The overall mean adherence score by local health area ranges from a low of 11.21 in Mission to a high of 12.80 in Langley.

Table 4-12 Adults with Diagnosed Type 2 Diabetes
Mean Adherence Scores

	Gender								
	Female			Male			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Total Sample	12.37	12.29	12.45	11.94	11.87	12.01	12.14	12.08	12.19
By Age *(in year 3)*									
30-39	10.66	10.30	11.02	10.35	10.03	10.66	10.50	10.27	10.74
40-49	11.73	11.51	11.95	10.95	10.76	11.14	11.29	11.15	11.43
50-59	12.45	12.29	12.61	11.58	11.44	11.72	11.95	11.84	12.05
60-69	12.88	12.74	13.02	12.56	12.44	12.69	12.70	12.61	12.79
70-79	12.42	12.27	12.56	12.49	12.33	12.64	12.45	12.34	12.55
By Socio-Economic Status *(in year 3)*									
Quintile 1 (Low)	12.26	12.10	12.43	11.69	11.52	11.86	11.98	11.86	12.10
Quintile 2	12.17	12.00	12.34	12.03	11.87	12.19	12.10	11.98	12.21
Quintile 3	12.44	12.27	12.60	11.85	11.69	12.00	12.12	12.01	12.23
Quintile 4	12.58	12.40	12.77	12.14	11.98	12.29	12.33	12.21	12.45
Quintile 5 (High)	12.60	12.37	12.82	12.03	11.84	12.22	12.26	12.11	12.40
By Morbidity									
Very Low	9.65	8.80	10.50	8.79	8.29	9.30	9.06	8.63	9.50
Low	10.59	10.30	10.89	10.25	10.04	10.46	10.36	10.19	10.53
	11.70	11.53	11.87	11.32	11.18	11.47	11.48	11.37	11.59
High	12.69	12.57	12.82	12.38	12.26	12.49	12.53	12.44	12.61
Very High	13.07	12.94	13.20	13.06	12.93	13.20	13.07	12.97	13.16
By Disease-Specific Severity Index									
No Complications	11.19	11.03	11.35	10.89	10.76	11.01	11.01	10.91	11.11
1 or More Minor Complications	12.35	12.23	12.48	11.97	11.85	12.08	12.14	12.06	12.23
1 or More Intermediate Complications	13.30	13.17	13.42	13.08	12.95	13.21	13.19	13.10	13.28
1 Major Complication	13.01	12.43	13.58	12.76	12.14	13.38	12.90	12.48	13.32
2 or More Major Complications	13.19	12.56	13.82	12.75	12.15	13.36	12.96	12.53	13.40
By Patient Residence *(in year 3)*									
LHA 202 - S. Surrey / White Rock	13.02	12.68	13.36	12.40	12.11	12.70	12.68	12.45	12.90
LHA 201 - Surrey	12.19	12.03	12.35	11.78	11.63	11.92	11.97	11.87	12.08
LHA 076 - Agassiz-Harrison	11.74	10.90	12.57	12.75	11.83	13.67	12.08	11.44	12.72
LHA 075 - Mission	11.17	10.70	11.65	11.27	10.81	11.72	11.21	10.88	11.54
LHA 043 - Coquitlam	12.40	12.18	12.63	11.72	11.51	11.92	12.02	11.87	12.18
LHA 042 - Maple Ridge	11.87	11.57	12.17	11.26	10.96	11.50	11.55	11.33	11.76
LHA 041 - Burnaby	12.94	12.75	13.14	12.27	12.08	12.46	12.58	12.44	12.72
LHA 040 - New Westminster	12.48	12.11	12.85	12.40	12.04	12.75	12.44	12.18	12.69
LHA 037 - Delta	12.19	11.89	12.50	11.86	11.59	12.12	12.01	11.81	12.21
LHA 035 - Langley	13.02	12.73	13.31	12.62	12.35	12.89	12.80	12.61	13.00
LHA 034 - Abbotsford	11.68	11.43	11.93	11.58	11.34	11.83	11.62	11.45	11.80
LHA 033 - Chilliwack	12.47	12.14	12.80	11.97	11.67	12.26	12.17	11.95	12.39
LHA 032 - Hope	11.36	10.33	12.40	12.30	11.26	13.34	11.82	11.10	12.54

The overall mean score of 12.14 suggests that, on average, 53% of the recommended tests or procedures were received by the study population over the five year period from 1996/97 to 2000/01. This compares to the finding in the study by McGlynn and co-authors (2003) that individuals with diagnosed diabetes in the United States received just 45% of the processes recommended for basic care of diabetes.

The range by geographic location of residence from 11.21 (49% of recommended tests) to 12.80 (56% of recommended tests) is substantially narrower than the unadjusted range observed between US states. Work by Jencks et al. (2000), for example, found that adherence varied significantly by US state, from 52 to 85% for annual HbA1c testing, 56 to 80% for biennial eye exams and 39 to 73% for biennial lipid profiles. A key difference in the current study, however, is that the measure of adherence is based on the repeated receipt of recommended clinical procedures during a five year period.

Do the individual adherence measures cluster? Is a patient who visits their GP four or more times per year more likely to receive optimal levels of the diagnostic procedures recommended for the management of diabetes? The crosstabulation data in tables 4-13 to 4-15 was prepared to help address this question.

In the study design, it was assumed that every visit to a general practitioner would include a blood pressure reading, since this is common practice. The diagnostic tests were discreet billable procedures, clearly identifiable in the MSP database. Thus, it was possible to tabulate the diagnostic procedures for each patient and look for patterns.

Tables 4-13 through 4-15 provide crosstabulation data for the years from 1999 to 2001. Just 49% of patients who see there GP four or more times per year also receive two or more HbA1c tests. The findings reveal a slight improvement over time (to 55% for HbA1c). The same

result is seen for the other measures. There is no strong evidence that seeing a family physician four times a year resulted in optimal diagnostic care for patients with diabetes. Thus simply increasing the number of visits to a GP does not appear to assure that the recommended clinical procedures will be received in a timely fashion.

Table 4-13 Relationship Between Individual Adherence Measures
Fiscal 1998/99

	Individual Adherence Measure				
	HbA1C	Eye	Micro	BP	Lipid
Population	20,228	20,228	20,228	20,228	20,228
# with Measure	9,293	8,080	5,215	17,051	15,603
% with Measure	45.9%	39.9%	25.8%	84.3%	77.1%

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**9,293**	4,267	3,441	8,386	7,838
Eye	4,267	**8,080**	2,463	7,020	6,392
Micro	3,441	2,463	**5,215**	4,534	4,560
BP	8,386	7,020	4,534	**17,051**	13,312
Lipid	7,838	6,392	4,560	13,312	**15,603**

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**100%**	46%	37%	90%	84%
Eye	53%	**100%**	30%	87%	79%
Micro	66%	47%	**100%**	87%	87%
BP	49%	41%	27%	**100%**	78%
Lipid	50%	41%	29%	85%	**100%**

Table 4-14 Relationship Between Individual Adherence Measures

Fiscal 1999/00

	Individual Adherence Measure				
	HbA1C	Eye	Micro	BP	Lipid
Population	20,228	20,228	20,228	20,228	20,228
# w Measure	10,035	8,260	6,906	17,411	16,265
% w Measure	49.6%	40.8%	34.1%	86.1%	80.4%

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**10,035**	4,739	4,705	9,150	8,704
Eye	4,739	**8,260**	3,236	7,330	6,882
Micro	4,705	3,236	**6,906**	6,115	6,241
BP	9,150	7,330	6,115	**17,411**	14,114
Lipid	8,704	6,882	6,241	14,114	**16,265**

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**100%**	47%	47%	91%	87%
Eye	57%	**100%**	39%	89%	83%
Micro	68%	47%	**100%**	89%	90%
BP	53%	42%	35%	**100%**	81%
Lipid	54%	42%	38%	87%	**100%**

Table 4-15 Relationship Between Individual Adherence Measures

Fiscal 2000/01

	Individual Adherence Measure				
	HbA1C	Eye	Micro	BP	Lipid
Population	20,228	20,228	20,228	20,228	20,228
# w Measure	10,468	7,977	7,607	17,279	16,641
% w Measure	51.8%	39.4%	37.6%	85.4%	82.3%

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**10,468**	4,815	5,354	9,513	9,332
Eye	4,815	**7,977**	3,421	7,085	6,800
Micro	5,354	3,421	**7,607**	6,742	7,039
BP	9,513	7,085	6,742	**17,279**	14,406
Lipid	9,332	6,800	7,039	14,406	**16,641**

	HbA1C	Eye	Micro	BP	Lipid
HbA1C	**100%**	46%	51%	91%	89%
Eye	60%	**100%**	43%	89%	85%
Micro	70%	45%	**100%**	89%	93%
BP	55%	41%	39%	**100%**	83%
Lipid	56%	41%	42%	87%	**100%**

4.3.2 Adherence Analyzed as a Categorical Variable (Low, Med, High)

Overall, 25.4% (5,136) of adults with diagnosed type 2 diabetes were in the low adherence group, 46.7% (9,448) were in the medium adherence group and 27.9% (5,644) were in the high adherence group. Descriptive information on adherence as a categorical variable is provided in table 4-16.

Table 4-16 Proportion of Adults with Diagnosed Type 2 Diabetes
With Low, Medium or High Adherence

	Adherence								
	Low			Medium			High		
	%	95% CI		%	95% CI		%	95% CI	
Total Population	25.4%	24.8%	26.0%	46.7%	46.0%	47.4%	27.9%	27.3%	28.5%
By Sex									
Female	23.4%	22.6%	24.3%	46.6%	45.6%	47.7%	29.9%	29.0%	30.9%
Male	27.0%	26.2%	27.9%	46.8%	45.8%	47.7%	26.2%	25.4%	27.0%
By Age *(in Year 3)*									
30-39	41.5%	38.6%	44.5%	41.5%	38.6%	44.5%	17.0%	14.9%	19.3%
40-49	32.7%	31.0%	34.5%	46.1%	44.2%	47.9%	21.2%	19.8%	22.8%
50-59	26.9%	25.7%	28.2%	47.2%	45.8%	48.6%	25.9%	24.7%	27.1%
60-69	20.4%	19.5%	21.5%	47.5%	46.3%	48.8%	32.0%	30.9%	33.2%
70-79	22.5%	21.4%	23.7%	46.7%	45.3%	48.0%	30.8%	29.6%	32.1%
By Socio-Economic Status (in Year 3)									
Quintile 1 (Low)	27.2%	25.9%	28.6%	46.0%	44.5%	47.6%	26.7%	25.4%	28.1%
Quintile 2	25.4%	24.1%	26.7%	47.4%	45.9%	48.9%	27.2%	25.9%	28.6%
Quintile 3	25.6%	24.3%	26.8%	47.0%	45.6%	48.5%	27.4%	26.2%	28.7%
Quintile 4	23.7%	22.4%	25.0%	46.7%	45.2%	48.2%	29.6%	28.2%	31.0%
Quintile 5 (High)	24.5%	22.9%	26.1%	46.1%	44.2%	48.0%	29.5%	27.8%	31.2%
By Morbidity									
Very Low	53.0%	47.6%	58.3%	36.5%	31.6%	41.8%	10.5%	7.6%	14.2%
Low	42.5%	40.4%	44.5%	41.4%	39.3%	43.4%	16.2%	14.7%	17.8%
Medium	31.5%	30.2%	32.9%	46.8%	45.3%	48.2%	21.7%	20.5%	22.9%
High	21.4%	20.5%	22.4%	48.0%	46.9%	49.2%	30.5%	29.5%	31.6%
Very High	17.0%	16.0%	18.0%	48.0%	46.7%	49.3%	35.1%	33.8%	36.3%
By Disease-Specific Severity Index									
No Complications	36.4%	35.2%	37.6%	43.3%	42.1%	44.5%	20.3%	19.3%	21.3%
1 or More Minor Complications	24.4%	23.4%	25.5%	49.6%	48.4%	50.8%	26.0%	25.0%	27.0%
1 or More Intermediate Complications	16.0%	15.2%	17.0%	47.1%	45.9%	48.4%	36.8%	35.6%	38.0%
1 Major Complication	18.0%	14.3%	22.5%	45.6%	40.3%	50.9%	36.4%	31.4%	41.7%
2 or More Major Complications	18.2%	14.2%	23.2%	44.2%	38.6%	50.0%	37.5%	32.1%	43.3%
By Patient Residence (in Year 3)									
LHA 202 - S. Surrey / White Rock	18.8%	16.6%	21.3%	47.7%	44.7%	50.8%	33.4%	30.6%	36.4%
LHA 201 - Surrey	26.5%	25.3%	27.8%	47.9%	46.5%	49.3%	25.6%	24.4%	26.9%
LHA 076 - Agassiz-Harrison	21.1%	14.9%	29.2%	51.2%	42.5%	59.9%	27.6%	20.5%	36.1%
LHA 075 - Mission	34.8%	30.9%	38.8%	43.7%	39.6%	47.8%	21.6%	18.4%	25.2%
LHA 043 - Coquitlam	26.7%	25.0%	28.5%	46.1%	44.1%	48.1%	27.2%	25.5%	29.0%
LHA 042 - Maple Ridge	28.5%	25.9%	31.3%	50.8%	47.8%	53.8%	20.7%	18.4%	23.3%
LHA 041 - Burnaby	22.8%	21.4%	24.3%	43.8%	42.1%	45.5%	33.4%	31.8%	35.0%
LHA 040 - New Westminster	23.4%	20.7%	26.2%	46.7%	43.5%	50.0%	29.9%	27.0%	33.0%
LHA 037 - Delta	25.6%	23.4%	28.0%	47.8%	45.2%	50.4%	26.6%	24.3%	28.9%
LHA 035 - Langley	20.2%	18.3%	22.3%	45.2%	42.7%	47.7%	34.6%	32.3%	37.0%
LHA 034 - Abbotsford	30.5%	28.4%	32.6%	47.1%	44.9%	49.4%	22.4%	20.5%	24.4%
LHA 033 - Chilliwack	23.1%	20.7%	25.8%	48.9%	45.9%	51.9%	27.9%	25.3%	30.7%
LHA 032 - Hope	33.8%	26.3%	42.2%	38.3%	30.5%	46.8%	27.8%	20.9%	36.0%

The data in table 4-16 confirms the findings in the previous section based on adherence as a continuous variable with only minor differences. A higher proportion of females (29.9%) are in the high adherence category compared to males (26.2%). The proportion of individuals in the high adherence category tends to increase with age and higher levels of morbidity. Interestingly, there appears to be a marginal increase in the proportion of individuals in the high adherence category with a higher socio-economic status (quintiles 4) compared to individuals with a low socio-economic status (quintile 1). The proportion of individuals in the high adherence category by local health area ranges from a low of 20.7% in Maple Ridge to a high of 34.6% in Langley.

4.3.3 Adherence Analyzed as a Binary Variable (Low, High)

Descriptive information on adherence as a binary variable is provided in table 4-17. Adherence scores from 0-12 were used to create the low adherence category and 13-23 to create the high adherence category. Overall, 53.3% (10,788) of adults with diagnosed type 2 diabetes were in the low adherence group while 46.7% (9,440) were in the high adherence group.

The data presented in table 4-17 confirms many of the earlier findings based on adherence as both a continuous and a categorical variable, again with some minor differences. A higher proportion of females (49.2%) are in the high adherence category compared to males (44.6%). In addition, the proportion of individuals in the high adherence category tends to increase with age and higher levels of morbidity. The tenuous relationship between adherence and socio-economic status is no longer statistically significant. The proportion of individuals in the high adherence category by local health area ranges from 38.1% in Mission to 54.1% in Langley.

Table 4-17 Proportion of Adults With Diagnosed Type 2 Diabetes With Low or High Adherence

	Adherence					
	Low			High		
	%	95% CI		%	95% CI	
Total Population	53.3%	52.6%	54.0%	46.7%	46.0%	47.4%
By Sex						
Female	50.8%	49.8%	51.9%	49.2%	48.2%	50.2%
Male	55.4%	54.5%	56.4%	44.6%	43.6%	45.5%
By Age *(in Year 3)*						
30-39	68.5%	65.6%	71.2%	31.5%	28.9%	34.4%
40-49	62.3%	60.5%	64.1%	37.7%	35.9%	39.5%
50-59	55.8%	54.4%	57.2%	44.2%	42.8%	45.6%
60-69	47.4%	46.1%	48.6%	52.6%	51.4%	53.9%
70-79	49.9%	48.6%	51.3%	50.1%	48.7%	51.4%
By Socio-Economic Status (in Year 3)						
Quintile 1 (Low)	54.6%	53.0%	56.1%	45.4%	43.9%	47.0%
Quintile 2	53.5%	52.0%	55.0%	46.5%	45.1%	48.0%
Quintile 3	53.7%	52.3%	55.2%	46.3%	44.9%	47.7%
Quintile 4	51.8%	50.2%	53.3%	48.2%	46.7%	49.8%
Quintile 5 (High)	52.1%	50.3%	54.0%	47.9%	46.0%	49.7%
By Morbidity						
Very Low	79.0%	74.4%	83.1%	21.0%	16.9%	25.6%
Low	70.6%	68.7%	72.5%	29.4%	27.5%	31.4%
Medium	60.7%	59.2%	62.1%	39.3%	37.9%	40.8%
High	49.9%	48.8%	51.1%	50.1%	48.9%	51.2%
Very High	43.5%	42.2%	44.8%	56.5%	55.2%	57.8%
By Disease-Specific Severity Index						
No Complications	64.3%	63.1%	65.5%	35.7%	34.5%	36.9%
1 or More Minor Complications	54.3%	53.1%	55.4%	45.7%	44.6%	46.9%
1 or More Intermediate Complications	42.2%	41.0%	43.4%	57.8%	56.6%	59.0%
1 Major Complication	43.2%	38.0%	48.5%	56.8%	51.5%	62.0%
2 or More Major Complications	43.0%	37.2%	48.6%	57.0%	51.4%	62.8%
By Patient Residence (in Year 3)						
LHA 202 - S. Surrey / White Rock	47.5%	44.5%	50.6%	52.5%	49.4%	55.5%
LHA 201 - Surrey	55.2%	53.8%	56.6%	44.8%	43.4%	46.2%
LHA 076 - Agassiz-Harrison	51.2%	42.5%	59.9%	48.8%	40.1%	57.5%
LHA 075 - Mission	62.0%	57.8%	65.8%	38.0%	34.2%	42.2%
LHA 043 - Coquitlam	54.8%	52.9%	56.8%	45.2%	43.2%	47.2%
LHA 042 - Maple Ridge	61.6%	58.7%	64.5%	38.4%	35.5%	41.3%
LHA 041 - Burnaby	47.2%	45.5%	48.9%	52.8%	51.1%	54.6%
LHA 040 - New Westminster	51.2%	47.9%	54.4%	48.8%	45.6%	52.1%
LHA 037 - Delta	54.0%	51.4%	56.6%	46.0%	43.4%	48.6%
LHA 035 - Langley	45.9%	43.5%	48.4%	54.1%	51.6%	56.5%
LHA 034 - Abbotsford	59.5%	57.2%	61.7%	40.5%	38.3%	42.8%
LHA 033 - Chilliwack	54.0%	51.1%	57.1%	46.0%	43.0%	48.9%
LHA 032 - Hope	56.4%	47.9%	64.5%	43.6%	35.5%	52.1%

In conclusion, when assessing long-term adherence to recommended clinical procedures, the results were similar for this study sample regardless of whether the summary adherence scores were provided as a continuous, categorical or binary variable. The robust findings were that:

- Females tended to have higher adherence scores than males.
- Adherence improved with increasing age and higher levels of morbidity.
- Several LHAs tended to remain on the lower (Mission and Maple Ridge) or higher end of adherence (Langley).

4.3.4 Adherence by Age, Morbidity and Gender

Tables 4-18 to 4-20 provide information on mean adherence scores by age, morbidity and gender. Overall, mean adherence scores increase significantly by age from 10.5 for 30-39 year olds to 12.7 for 60-69 years before declining to 12.5 for 70-79 year olds. Similar age-related trends are seen for both females and males.

Mean adherence scores also increase significantly with the level of morbidity. Individuals with a very low level of morbidity have a mean adherence score of 9.1 while those with a very high level of morbidity have a mean adherence score of 13.1 (95% CI of 13.0, 13.2). As with the trend for age, this trend is seen for both females and males.

Table 4-18 Adults with Diagnosed Type 2 Diabetes
Mean Adherence Scores
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	8.3	6.5	10.0	8.9	8.2	9.5	10.1	9.6	10.6	11.1	10.7	11.5	11.7	11.2	12.2	**10.5**	**10.3**	**10.7**
40-49	7.9	6.9	8.9	9.3	8.9	9.7	10.7	10.4	10.9	11.8	11.6	12.1	12.6	12.4	12.9	**11.3**	**11.2**	**11.4**
50-59	8.3	7.6	9.0	10.3	10.0	10.6	11.4	11.1	11.6	12.4	12.3	12.6	13.1	12.9	13.3	**11.9**	**11.8**	**12.1**
60-69	10.4	9.6	11.2	11.2	10.9	11.5	12.2	12.0	12.3	13.0	12.9	13.2	13.4	13.2	13.5	**12.7**	**12.6**	**12.8**
70-79	9.7	8.5	10.8	10.5	10.1	11.0	11.7	11.5	12.0	12.6	12.5	12.8	13.1	13.0	13.3	**12.5**	**12.3**	**12.6**
Total	**9.1**	**8.6**	**9.5**	**10.4**	**10.2**	**10.5**	**11.5**	**11.4**	**11.6**	**12.5**	**12.4**	**12.6**	**13.1**	**13.0**	**13.2**	**12.1**	**12.1**	**12.2**

Table 4-19 Females with Diagnosed Type 2 Diabetes
Mean Adherence Scores
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	7.5	1.2	13.9	8.4	7.3	9.6	10.2	9.4	11.0	11.3	10.6	11.9	12.0	11.4	12.6	**10.7**	**10.3**	**11.0**
40-49	9.1	6.3	12.0	9.4	8.6	10.2	10.9	10.4	11.3	12.2	11.8	12.5	12.7	12.3	13.0	**11.7**	**11.5**	**12.0**
50-59	7.9	6.4	9.4	10.7	10.2	11.3	11.7	11.4	12.1	12.7	12.5	13.0	13.4	13.1	13.7	**12.5**	**12.3**	**12.6**
60-69	11.5	10.1	12.9	11.2	1.1	11.7	12.4	12.1	12.7	13.1	12.9	13.4	13.5	13.2	13.7	**12.9**	**12.7**	**13.0**
70-79	9.5	7.7	11.2	10.7	10.0	11.3	11.7	11.4	12.1	12.7	12.4	12.9	12.8	12.6	13.1	**12.4**	**12.3**	**12.6**
Total	**9.7**	**8.8**	**10.5**	**10.6**	**10.3**	**10.9**	**11.7**	**11.5**	**11.9**	**12.7**	**12.6**	**12.8**	**13.1**	**12.9**	**13.2**	**12.4**	**12.3**	**12.5**

Table 4-20 Males with Diagnosed Type 2 Diabetes
Mean Adherence Scores
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	8.4	6.3	10.4	9.0	8.2	9.9	10.1	9.5	10.6	10.9	10.4	11.4	11.3	10.4	12.2	**10.4**	**10.0**	**10.7**
40-49	7.5	6.4	8.5	9.3	8.8	9.8	10.5	10.2	10.8	11.6	11.2	11.9	12.6	12.2	13.0	**11.0**	**10.8**	**11.1**
50-59	8.5	7.7	9.3	10.1	9.7	10.4	11.1	10.9	11.4	12.2	12.0	12.4	12.7	12.4	13.0	**11.6**	**11.4**	**11.7**
60-69	9.7	8.7	10.7	11.2	10.9	11.6	12.0	11.8	12.3	13.0	12.8	13.2	13.3	13.1	13.6	**12.6**	**12.4**	**12.7**
70-79	9.8	8.2	11.5	10.5	9.9	11.1	11.7	11.3	12.1	12.6	12.3	12.8	13.5	13.2	13.7	**12.5**	**12.3**	**12.6**
Total	**8.8**	**8.3**	**9.3**	**10.3**	**10.0**	**10.5**	**11.3**	**11.2**	**11.5**	**12.4**	**12.3**	**12.5**	**13.1**	**12.9**	**13.2**	**11.9**	**11.9**	**12.0**

Overall, females have a higher mean adherence score (12.4) than males (11.9). This difference in adherence between males and females is most noticeable in individuals who are still relatively healthy. At the very high level of morbidity, both male and female mean adherence scores are virtually identical at 13.1.

4.3.5 Trends in Adherence over Time for Low and High Adherence Groups

We noted in section 4.2.2 Trend Analysis that a significant positive linear trend was evident for the proportion of individuals who received all five recommended clinical procedures during the year. In other words there was a consistent, predictable improvement in this component in adherence. Conversely, the analysis of single diagnostic procedures revealed non linear improvement, which was not consistent and predictable, but nevertheless encouraging. Are there differences in this trend if only individuals in the low or high adherence groups are examined?

Table 4-21 provides information on the trends in adherence associated with each of the individual adherence variables for the low adherence group (n=5,136) while table 4-22 provides this information for the high adherence group (n=5,644).

For both low and high adherence groups, there was a significant positive linear trend with almost all individual adherence variables showing improvement from year one to year five. One exception was eye exams for the low adherence group, in which adherence improved during the first two years but then declined in the final two years. There was also a significant non-linear component to the trend for all individual adherence variables. This suggests significant improvements in adherence over time for the low and high adherence groups but that the improvement was not consistent and predictable as evidenced by a slope that fluctuated year by year.

Table 4-21 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving the Following Recommended Services
High Adherence Group

	Fiscal Year					Test for Trend: *Linear*			*Quadratic*			*Cubic*		
	1996/97	1997/98	1998/99	1999/00	2000/01	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Two or More HbA1C Tests During the Year	62.1%	74.3%	77.2%	79.9%	82.3%	0.458	0.420	0.496	-0.198	-0.238	-0.160	0.088	0.057	0.120
At Least One Retinal Eye Exam During the Year	59.6%	64.9%	64.5%	66.1%	64.9%	0.118	0.084	0.153	-0.112	-0.159	-0.067	0.028	-0.007	0.063
At least One Microalbumin Test During the Year	28.3%	40.0%	47.8%	57.3%	61.0%	0.830	0.792	0.869	-0.142	-0.184	-0.100	-0.018	-0.057	0.019
At Least One Lipid Test Every Three Years		92.7%	95.2%	95.6%										
At least Four Blood Pressure Measurements During the Year	92.2%	94.4%	94.4%	95.1%	95.1%	0.065	0.046	0.086	-0.039	-0.060	-0.018	0.014	-0.002	0.031
Received all Services	11.7%	18.2%	20.8%	27.5%	28.6%	0.431	0.398	0.464	-0.067	-0.106	-0.029	-0.019	-0.051	0.013
Received None of the Services	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	-0.001	0.001	0.000	-0.001	0.001	0.001	-0.001	0.000

Note: N=5,644

Table 4-22 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving the Following Recommended Services
Low Adherence Group

	Fiscal Year					Test for Trend: *Linear*			*Quadratic*			*Cubic*		
	1996/97	1997/98	1998/99	1999/00	2000/01	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Two or More HbA1C Tests During the Year	11.3%	14.5%	15.4%	17.3%	18.3%	0.168	0.138	0.199	-0.036	-0.070	-0.003	0.013	-0.017	0.042
At Least One Retinal Eye Exam During the Year	15.3%	17.3%	17.8%	16.9%	15.5%	0.000	-0.029	0.030	-0.082	-0.116	-0.045	0.008	-0.021	0.038
At least One Microalbumin Test During the Year	3.4%	6.5%	7.4%	13.5%	14.5%	0.291	0.267	0.317	0.008	-0.018	0.038	-0.027	-0.050	-0.004
At Least One Lipid Test Every Three Years		53.3%	56.1%	59.0%										
At least Four Blood Pressure Measurements During the Year	65.7%	70.9%	69.1%	71.6%	69.3%	0.080	0.042	0.119	-0.107	-0.145	-0.064	0.021	-0.009	0.052
Received all Services	0.2%	0.2%	0.1%	0.4%	0.5%	0.010	0.005	0.015	0.005	0.000	0.011	0.000	-0.005	0.005
Received None of the Services	10.0%	6.6%	6.3%	6.9%	8.4%	-0.030	-0.054	-0.003	0.107	0.082	0.132	-0.022	-0.042	-0.004

Note: N=5,136

4.4 Univariate Logistic Regression Models for Adherence

As stated earlier, medical staff and patients need to work together to reach optimal blood glucose, blood pressure and cholesterol levels. Which patient characteristics have a significant effect on whether or not adults with diagnosed type 2 diabetes are in the high versus low adherence category? Table 4-23 provides the results of the univariate logistic regression models comparing the high versus low adherence groups.

Table 4-23 Univariate Logistic Regression Models for High vs. Low Adherence

	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper	-2 log likelihood	Model X^2	df	*p* -value	Nagelkerke R Square	Selection
By Sex													
Female	0.185	0.028	42.5	< 0.001	1.203	1.138	1.272	27,834.3	42.5	1	< 0.001	0.003	Yes
Male	*******												
By Age *(in Year 3)*													
30-39	-0.540	0.071	57.4	< 0.001	0.583	0.507	0.670	27,633.7	318.4	4	< 0.001	0.021	Yes
40-49	-0.269	0.048	31.1	< 0.001	0.764	0.699	0.840						
50-59	*******												
60-69	0.339	0.038	79.2	< 0.001	1.403	1.302	1.512						
70-79	0.235	0.040	32.5	< 0.001	1.268	1.173	1.371						
By Socio-Economic Status (in Year 3)													
Quintile 1 (Low)	-0.034	0.043	0.6	0.437	0.967	0.888	1.052	27,406.9	8.2	4	0.085	0.001	Yes
Quintile 2	0.010	0.042	0.1	0.817	1.010	0.929	1.097						
Quintile 3	*******												
Quintile 4	0.079	0.043	3.4	0.067	1.082	0.995	1.177						
Quintile 5 (High)	0.062	0.048	1.7	0.197	1.064	0.968	1.170						
By Morbidity													
Very Low	-0.894	0.138	42.1	< 0.001	0.409	0.312	0.536	27,047.7	719.3	4	< 0.001	0.047	Yes
Low	-0.442	0.056	62.3	< 0.001	0.643	0.576	0.717						
Medium	*******												
High	0.437	0.038	130.0	< 0.001	1.548	1.436	1.668						
Very High	0.696	0.041	292.6	< 0.001	2.006	1.852	2.172						
By Disease-Specific Severity Index													
No Complications	-0.902	0.037	609.0	< 0.001	0.406	0.378	0.436	27,298.7	653.4	4	< 0.001	0.042	Yes
1 or More Minor Comp.	-0.485	0.035	191.0	< 0.001	0.616	0.575	0.660						
1 or More Intermediate Comp.	*******												
1 Major Comp.	-0.040	0.113	0.1	0.723	0.961	0.770	1.198						
2 or More Major Comp.	-0.030	0.123	0.1	0.805	0.970	0.763	1.234						
By Patient Residence (in Year 3)													
LHA 202 - S. Surrey / WR	0.308	0.069	20.2	< 0.001	1.361	1.190	1.557	27,767.4	184.7	12	< 0.001	0.012	Yes
LHA 201 - Surrey	*******												
LHA 076 - Agassiz-Harrison	0.161	0.183	0.8	0.379	1.174	0.821	1.680						
LHA 075 - Mission	-0.279	0.092	9.2	0.002	0.757	0.632	0.906						
LHA 043 - Coquitlam	0.015	0.050	0.1	0.766	1.015	0.920	1.119						
LHA 042 - Maple Ridge	-0.265	0.070	14.5	< 0.001	0.767	0.669	0.879						
LHA 041 - Burnaby	0.322	0.045	50.2	< 0.001	1.380	1.262	1.508						
LHA 040 - New Westminster	0.163	0.073	5.0	0.025	1.177	1.021	1.357						
LHA 037 - Delta	0.049	0.061	0.7	0.416	1.051	0.933	1.184						
LHA 035 - Langley	0.373	0.058	40.9	< 0.001	1.453	1.296	1.629						
LHA 034 - Abbotsford	-0.175	0.056	9.9	0.002	0.839	0.753	0.936						
LHA 033 - Chilliwack	0.049	0.068	0.5	0.467	1.051	0.920	1.200						
LHA 032 - Hope	-0.048	0.177	0.1	0.791	0.953	0.674	1.349						

*Notes: ******* Reference Category*

In the absence of adjusting for other variables, females with diagnosed type 2 diabetes are 20.3% (odds ratio of 1.203) more likely to be in the high adherence category than men. On its own, however, the independent variable of gender explains just 0.03% (Nagelkerke R Square of 0.003) of the variance in the dependent variable of low or high adherence category.

As a next step in the analysis, adults in various age groups were compared to the reference group of adults aged 50 to 59. This reference group represented the middle of the age scale. Adults aged 30 to 39 were 41.7% less likely than were the reference group to be in the high adherence category. Likewise, adults aged 40 to 49 were 23.6% less likely to be in the high

adherence category. On the other hand, older individuals are more likely to be in the high adherence category. Those aged 60-69 were 40.3% more likely and those aged 70-79 were 26.8% more likely to be in the high adherence category compared to the reference group. The independent variable of age accounted for 2.1% of the variance in the dependent variable of low or high adherence.

Socio-economic status was selected for inclusion as a variable in the multivariate model. As noted in Section 3.7 Analytic Methods, any variable for which the univariate test has a p value of < 0.25 will be considered a candidate for the multivariate model. The 0.25 level has been suggested as an appropriate level for selection of candidate variables as the use of the more traditional level of 0.05 for variable selection often fails to uncover subtle findings. The analysis revealed that SES did not achieve formal statistical significance.

Adults with diagnosed type 2 diabetes who were in the very low and low morbidity groups were considerably less likely (59.1% and 35.7%, respectively) to be in the high adherence group than are those in the medium morbidity group. On the other hand, adults in the high or very high morbidity groups are more likely to be in the high adherence category (54.8% and 100.6%, respectively). The independent variable of morbidity accounted for 4.7% of the variance in the dependent variable of low or high adherence.

The reference group for disease-specific severity was those with one or more intermediate complications. Adults with diagnosed type 2 diabetes with no diabetes disease-specific complications or just one or more minor complications were considerably less likely (59.4% and 38.4%, respectively) to be in the high adherence group than the reference group. On the other hand, no significant differences existed between adults with one or more major complications when compared to the reference group. The independent variable of the disease-

specific severity index accounted for 4.2% of the variance in the dependent variable of low or high adherence.

Adults with diagnosed type 2 diabetes living in certain local health areas (LHA) are more or less likely to be in the high adherence group than are those who live in the LHA of Surrey (the reference group). Individuals living in the LHAs of New Westminster, South Surrey/White Rock, Burnaby and Langley are 17.7%, 36.1%, 38.0% and 45.3%, respectively, more likely to be in the high adherence group than individuals who live in the LHA of Surrey. Individuals living in the LHAs of Abbotsford, Maple Ridge and Mission are 16.1%, 23.3%, and 24.3%, respectively, less likely to be in the high adherence group than individuals who live in the LHA of Surrey. The independent variable of patient residence accounts for 1.2% of the variance in the dependent variable of low or high adherence.

4.5 Multivariate Logistic Regression Model for Adherence

4.5.1 Development of a Reduced Main Effects Model for Adherence

As noted in table 4-23, all six of the independent variables assessed in the univariate analysis were selected for inclusion in the multivariate model. The variables were entered into the Binary Logistic Regression function of SPSS based on the explanatory power of the variable. Thus the variable morbidity was entered first, followed by disease-specific severity index, age, patient residence, gender and socio-economic status. Once all of the variables were in the model, each variable was sequentially removed in reverse order to assess the impact of the exclusion of each variable from the full model. The results are provided in table 4-24.

Table 4-24 Development and Testing of a Multivariate Logistic Regression Model for High vs. Low Adherence

	Intermediate Models (Odds Ratios)					**Full Model**	Assessing the Impact of Removing Individual Variables					
By Sex					***0.001***	***<0.001***	***<0.001***	***<0.001***	***0.001***	***<0.001***		***0.001***
Female					1.102	1.112	1.168	1.125	1.109	1.115		1.102
Male	*******											
By Age *(in Year 3)*			***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***
30-39			0.631	0.650	0.647	0.647	0.651	0.599		0.630	0.648	0.647
40-49			0.805	0.808	0.806	0.817	0.825	0.780		0.815	0.817	0.806
50-59	*******											
60-69			1.293	1.288	1.286	1.294	1.295	1.358		1.299	1.294	1.286
70-79			1.040	1.030	1.021	1.035	1.069	1.136		1.045	1.044	1.021
By Socio-Economic Status (in Year 3)						***0.034***	***0.147***	***0.044***	***0.021***	***0.001***	***0.047***	
Quintile 1 (Low)						0.895	0.919	0.895	0.897	0.907	0.896	
Quintile 2						0.981	0.993	0.980	0.978	0.995	0.983	
Quintile 3	*******											
Quintile 4						1.018	1.019	1.015	1.027	1.080	1.013	
Quintile 5 (High)						1.041	1.036	1.032	1.056	1.078	1.032	
By Morbidity	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Very Low	0.409	0.462	0.451	0.445	0.452	0.453		0.408	0.463	0.458	0.448	0.452
Low	0.643	0.684	0.675	0.671	0.675	0.672		0.638	0.681	0.676	0.667	0.675
Medium	*******											
High	1.548	1.402	1.398	1.410	1.403	1.402		1.516	1.407	1.392	1.409	1.403
Very High	2.006	1.657	1.663	1.682	1.668	1.680		1.958	1.676	1.664	1.695	1.668
By Disease-Specific Severity Index		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***
No Complications		0.513	0.560	0.565	0.566	0.566	0.450		0.521	0.562	0.565	0.566
1 or More Minor Comp.		0.707	0.723	0.731	0.731	0.731	0.637		0.717	0.724	0.730	0.731
1 or More Intermediate Comp.	*******											
1 Major Comp.		0.897	0.948	0.949	0.942	0.940	1.009		0.891	0.939	0.947	0.942
2 or More Major Comp.		0.881	0.954	0.966	0.966	0.977	1.080		0.908	0.962	0.977	0.966
By Patient Residence (in Year 3)				***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***
LHA 202 - S. Surrey / WR				1.324	1.330	1.271	1.273	1.242	1.317		1.269	1.330
LHA 201 - Surrey	*******											
LHA 076 - Agassiz-Harrison				1.119	1.210	1.183	1.277	1.166	1.315		1.166	1.210
LHA 075 - Mission				0.765	0.771	0.762	0.766	0.744	0.769		0.754	0.771
LHA 043 - Coquitlam				1.038	1.041	1.006	0.971	1.019	1.017		1.005	1.041
LHA 042 - Maple Ridge				0.778	0.778	0.776	0.776	0.765	0.785		0.776	0.778
LHA 041 - Burnaby				1.404	1.404	1.384	1.331	1.381	1.423		1.385	1.404
LHA 040 - New Westminster				1.121	1.118	1.102	1.068	1.144	1.114		1.107	1.118
LHA 037 - Delta				1.060	1.059	1.004	0.991	1.018	1.002		1.008	1.059
LHA 035 - Langley				1.404	1.404	1.377	1.337	1.413	1.398		1.380	1.404
LHA 034 - Abbotsford				0.833	0.839	0.824	0.807	0.819	0.845		0.820	0.839
LHA 033 - Chilliwack				0.963	0.969	0.987	0.971	1.013	1.023		0.982	0.969
LHA 032 - Hope				0.875	0.887	0.856	0.910	0.826	0.884		0.844	0.887
-2 log likelihood	27,048	26,744	26,583	26,414	26,333	25,799	26,347	26,000	25,946	25,952	25,873	26,333
Likelihood Ratio Test X^2	719	1,023	1,184	1,353	1,358	1,345	983	1,145	1,198	1,192	1,338	1,358
Degrees of Freedom	4	8	12	24	25	29	25	25	25	17	28	25
p - value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nagelkerke R Square	0.047	0.066	0.076	0.087	0.088	0.088	0.065	0.076	0.079	0.079	0.088	0.088
Hosmer & Lemeshow GOF	1.000	0.014	< 0.001	0.321	0.504	0.351	0.417	0.349	0.532	0.043	0.371	0.504
Change in -2 Log Likelihood if Variable Removed							378.9	200.7	147.3	153.3	12.6	10.4
p - value of Change							< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.034

*Notes: ******* Reference Category*

Significant Odds Ratios (OR) are highlighted in yellow.

*The p-value for each (grouped) variable is provided in **bolded italics** above the first OR value for that group.*

Table 4-25 presents the detailed results of the main effects model. All six variables, including socio-economic status, were significant predictors of the probability of being in the high adherence group.

Table 4-25 Main Effects Multivariate Logistic Regression Model for High vs. Low Adherence

	p-value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Sex	***< 0.001***							
Female		0.106	0.030	12.6	< 0.001	1.112	1.049	1.180
Male		*******						
By Age *(in Year 3)*	***< 0.001***							
30-39		-0.436	0.077	32.0	< 0.001	0.647	0.556	0.752
40-49		-0.203	0.050	16.3	< 0.001	0.817	0.740	0.901
50-59		*******						
60-69		0.257	0.040	41.7	< 0.001	1.294	1.196	1.399
70-79		0.035	0.043	0.7	0.416	1.035	0.952	1.125
By Socio-Economic Status (in Year 3)	***0.034***							
Quintile 1 (Low)		-0.111	0.046	5.8	0.016	0.895	0.818	0.980
Quintile 2		-0.019	0.045	0.2	0.668	0.981	0.899	1.071
Quintile 3								
Quintile 4		0.018	0.045	0.1	0.700	1.018	0.931	1.113
Quintile 5 (High)		0.040	0.052	0.6	0.443	1.041	0.940	1.153
By Morbidity	***< 0.001***							
Very Low		-0.792	0.141	31.7	< 0.001	0.453	0.344	0.597
Low		-0.397	0.058	47.7	< 0.001	0.672	0.600	0.752
Medium		*******						
High		0.338	0.040	71.7	< 0.001	1.402	1.297	1.517
Very High		0.519	0.044	141.0	< 0.001	1.680	1.542	1.830
By Disease-Specific Severity Index	***< 0.001***							
No Complications		-0.569	0.041	193.0	< 0.001	0.566	0.523	0.614
1 or More Minor Comp.		-0.314	0.037	70.8	< 0.001	0.731	0.679	0.786
1 or More Intermediate Comp.		*******						
1 Major Comp.		-0.062	0.117	0.3	0.598	0.940	0.748	1.182
2 or More Major Comp.		-0.023	0.127	0.0	0.857	0.977	0.762	1.254
By Patient Residence (in Year 3)	***< 0.001***							
LHA 202 - S. Surrey / WR		0.240	0.074	10.5	0.001	1.271	1.099	1.469
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		0.168	0.438	0.1	0.701	1.183	0.501	2.794
LHA 075 - Mission		-0.272	0.097	7.9	0.005	0.762	0.630	0.921
LHA 043 - Coquitlam		0.006	0.053	0.0	0.914	1.006	0.906	1.116
LHA 042 - Maple Ridge		-0.254	0.074	11.7	0.001	0.776	0.671	0.898
LHA 041 - Burnaby		0.325	0.048	46.7	< 0.001	1.384	1.261	1.519
LHA 040 - New Westminster		0.097	0.076	1.7	0.197	1.102	0.951	1.278
LHA 037 - Delta		0.004	0.066	0.0	0.954	1.004	0.883	1.142
LHA 035 - Langley		0.320	0.062	26.5	< 0.001	1.377	1.219	1.556
LHA 034 - Abbotsford		-0.193	0.059	10.9	0.001	0.824	0.735	0.925
LHA 033 - Chilliwack		-0.013	0.073	0.0	0.859	0.987	0.856	1.139
LHA 032 - Hope		-0.156	0.184	0.7	0.398	0.856	0.596	1.228

-2 log likelihood	25,799.0
Likelihood Ratio Test X^2	1,345.2
Degrees of Freedom	29
p - value	< 0.001
Nagelkerke R Square	0.088
Hosmer & Lemeshow GOF	0.351

*Notes: ******* Reference Category*

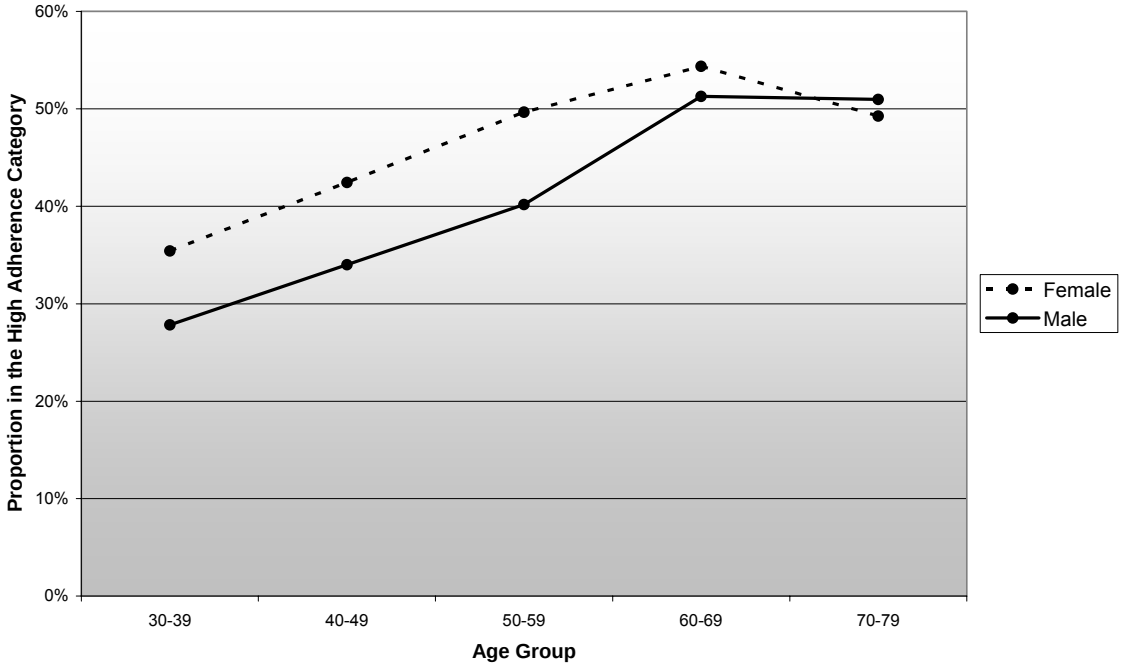
4.5.2 Development of a Final Fitted Model for Adherence

After the development of the main effects model, all possible two-way interactions were tested individually based on Wald statistics and their *p*-values. Each potential two-factor term was found to be significant. To assess these potential interactions in the model, the main effects were entered as a block and the potential two-way interactions were included as a second block using the Forward Stepwise (Likelihood Ratio) approach. This analysis identified two two-way interactions that remained significant after adjusting for the other variables in the model; morbidity by DSS Index (p=0.003) and age group by gender (p<0.001).

Each potential three-way interaction (based on the significant two-way interaction variables) was then tested individually based on Wald statistics and their *p*-values and found to be significant. The significant three-way interactions were then included with the two-way interactions in the second block. This analysis indicated that only the original two-way interactions remained significant after adjusting for the other variables in the model.

The interaction between age and gender is shown in figure 4-5. While younger females are consistently more likely to be in the high adherence category than males their age, this gap begins to close for individuals aged 60-69 and by age 70-79, closes completely. That is, males aged 70-79 are just as likely as females aged 70-79 to be in the high adherence category.

Figure 4-5 Age by Sex Interaction



The interaction between general and disease specific morbidity is shown on table 4-26.

Table 4-26 ACG by DSSI CrossTab

Low Adherence

	DSSIndex					
ACG	None	1+ Minor	1+ Int	1 Major	2+ Major	**Total**
Very Low	176	85	3	-	-	**264**
Low	888	524	128	1	2	**1,543**
Medium	1,207	1,315	1,089	68	39	**3,718**
High	485	839	985	64	71	**2,444**
Very High	1,279	989	440	12	10	**2,730**
Total	**4,035**	**3,752**	**2,645**	**145**	**122**	**10,699**

High Adherence

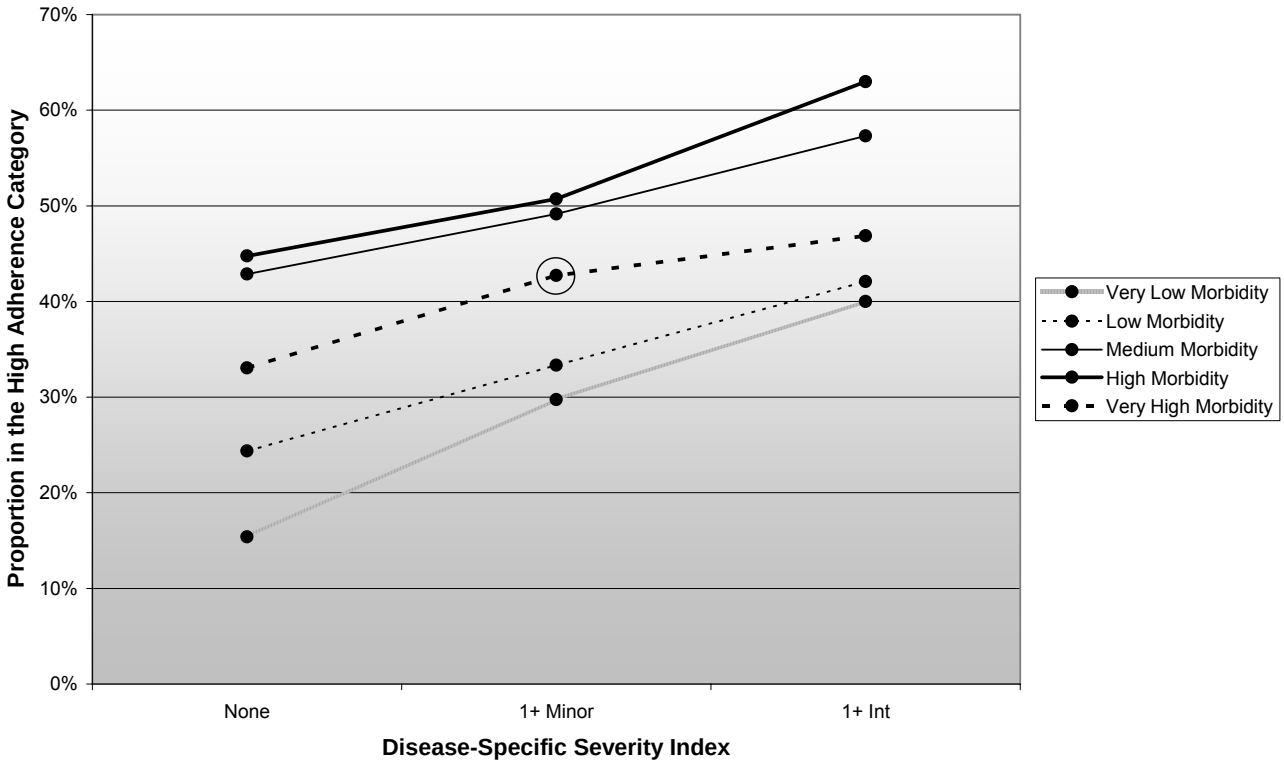
	DSSIndex					
ACG	None	1+ Minor	1+ Int	1 Major	2+ Major	**Total**
Very Low	32	36	2	0	0	**70**
Low	286	262	93	1	1	**643**
Medium	906	1271	1462	57	35	**3,731**
High	393	864	1676	120	125	**3,178**
Very High	631	738	388	12	1	**1,770**
Total	**2,248**	**3,171**	**3,621**	**190**	**162**	**9,392**

Percent High Adherence

	DSSIndex					
ACG	None	1+ Minor	1+ Int	1 Major	2+ Major	**Total**
Very Low	15%	30%	40%			**21%**
Low	24%	33%	42%	50%	33%	**29%**
Medium	43%	49%	57%	46%	47%	**50%**
High	45%	51%	63%	65%	64%	**57%**
Very High	33%	43%	47%	50%	9%	**39%**
Total	**36%**	**46%**	**58%**	**57%**	**57%**	**47%**

In figure 4-6, the same results are presented graphically but excluding unstable results caused by small cell sizes.

Figure 4-6 General by Disease-specific Morbidity Interaction



In general, adults with no disease-specific complications or one or more minor or intermediate disease-specific complications show a trend toward a higher probability of being in the high adherence category, regardless of their general morbidity status. The one significant interaction effect identified by the two-way interaction analysis (circled on figure 4-6, see also table 4-27) was that for the very high general morbidity by one or more minor disease-specific complications group.

The final fitted model, including the main effects and the two significant two-way interactions is shown on table 4-27.

Table 4-27 Final Fitted Multivariate Logistic Regression Model for High vs. Low Adherence

	p-value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Sex	***< 0.001***							
Female		0.290	0.060	23.3	< 0.001	1.336	1.188	1.502
Male		*******						
By Age *(in Year 3)*	***< 0.001***							
30-39		-0.437	0.106	16.9	< 0.001	0.646	0.525	0.796
40-49		-0.186	0.068	7.6	0.006	0.830	0.727	0.948
50-59		*******						
60-69		0.356	0.053	44.7	< 0.001	1.428	1.286	1.585
70-79		0.222	0.058	14.4	< 0.001	1.248	1.113	1.399
By Socio-Economic Status (in Year 3)	***0.054***							
Quintile 1 (Low)		-0.106	0.046	5.3	0.022	0.899	0.821	0.985
Quintile 2		-0.020	0.045	0.2	0.649	0.980	0.897	1.070
Quintile 3								
Quintile 4		0.014	0.046	0.1	0.753	1.014	0.928	1.109
Quintile 5 (High)		0.037	0.052	0.5	0.474	1.038	0.937	1.150
By Morbidity	***< 0.001***							
Very Low		-0.419	0.917	0.2	0.648	0.658	0.109	3.968
Low		-0.224	0.157	2.0	0.154	0.799	0.588	1.088
Medium		*******						
High		0.433	0.082	27.8	< 0.001	1.542	1.313	1.812
Very High		0.685	0.082	69.1	< 0.001	1.984	1.688	2.331
By Disease-Specific Severity Index	***< 0.001***							
No Complications		-0.474	0.088	29.4	< 0.001	0.622	0.524	0.739
1 or More Minor Comp.		-0.114	0.087	1.7	0.189	0.892	0.752	1.058
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.184	0.419	0.2	0.660	1.202	0.529	2.730
2 or More Major Comp.		-1.924	1.055	3.3	0.068	0.146	0.018	1.155
By Patient Residence (in Year 3)	***< 0.001***							
LHA 202 - S. Surrey / WR		0.237	0.074	10.2	0.001	1.268	1.096	1.466
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		0.193	0.439	0.2	0.659	1.213	0.513	2.868
LHA 075 - Mission		-0.269	0.097	7.7	0.006	0.764	0.632	0.924
LHA 043 - Coquitlam		0.007	0.053	0.0	0.889	1.007	0.908	1.118
LHA 042 - Maple Ridge		-0.246	0.074	11.0	0.001	0.782	0.676	0.904
LHA 041 - Burnaby		0.325	0.048	46.4	< 0.001	1.383	1.260	1.519
LHA 040 - New Westminster		0.097	0.076	1.7	0.199	1.102	0.950	1.278
LHA 037 - Delta		0.001	0.066	0.0	0.984	1.001	0.880	1.139
LHA 035 - Langley		0.317	0.062	25.8	< 0.001	1.373	1.215	1.551
LHA 034 - Abbotsford		-0.200	0.059	11.6	0.001	0.819	0.730	0.919
LHA 033 - Chilliwack		-0.015	0.073	0.0	0.841	0.985	0.854	1.137
LHA 032 - Hope		-0.166	0.185	0.8	0.368	0.847	0.589	1.216
Morbidity by DSSIndex	***0.003***							
Very Low by No Complications		-0.570	0.939	0.4	0.544	0.565	0.090	3.559
Very Low by 1+ Minor Complications		-0.176	0.941	0.0	0.851	0.838	0.133	5.298
Low by No Complications		-0.210	0.179	1.4	0.241	0.811	0.571	1.151
Low by 1+ Minor Complications		-0.191	0.182	1.1	0.294	0.826	0.579	1.180
Low by 1 Major Complication		0.427	1.483	0.1	0.773	1.533	0.084	28.036
Low by 2+ Major Complications		1.559	1.635	0.9	0.340	4.752	0.193	117.025
High by No Complications		-0.009	0.106	0.0	0.933	0.991	0.805	1.220
High by 1+ Minor Complications		-0.192	0.104	3.4	0.066	0.826	0.673	1.012
High by 1 Major Complication		-0.587	0.460	1.6	0.202	0.556	0.226	1.369
High by 2+ Major Complications		1.652	1.082	2.3	0.127	5.219	0.626	43.507
Very High by No Complications		-0.186	0.119	2.5	0.117	0.830	0.658	1.048
Very High by 1+ Minor Complications		-0.366	0.108	11.5	0.001	0.693	0.561	0.857
Very High by 1 Major Complication		-0.070	0.449	0.0	0.876	0.933	0.387	2.249
Very High by 2+ Major Complications		2.046	1.067	3.7	0.055	7.739	0.956	62.676
Age by Sex	***< 0.001***							
30-39 by Female		-0.012	0.154	0.0	0.941	0.989	0.730	1.338
40-49 by Female		-0.043	0.101	0.2	0.670	0.958	0.785	1.168
60-69 by Female		-0.229	0.080	8.2	0.004	0.795	0.680	0.930
70-79 by Female		-0.400	0.084	22.8	< 0.001	0.670	0.569	0.790

FITTED MODEL	-2 log likelihood	25,734.3
	Likelihood Ratio Test X^2	1,409.9
	Degrees of Freedom	47
	p - value	< 0.001
	Nagelkerke R Square	0.092
	Hosmer & Lemeshow GOF	0.677

4.5.3 Interpretation of the Final Fitted Model for Adherence

The multivariate analysis revealed results that contrasted with the results of the univariate analysis.

After adjusting for numerous covariates and interactions (i.e., age, socio-economic status, morbidity, disease-specific severity index, patient residence, interactions between morbidity and disease-specific severity index and age and gender), females with diagnosed type 2 diabetes were 33.6% more likely to be in the high adherence category than men. The earlier univariate analysis placed the increase at only 20.3%.

Younger adults remained less likely to be in the high adherence group compared to adults in the reference group (i.e., aged 50-59) while older adults are more likely to be in the high adherence group. This difference, however, was tempered somewhat after adjustment for the covariates in the model.

Interestingly, individuals in the lowest socio-economic status group were 10.1% less likely to be in the high adherence category compared to individuals in the middle socio-economic status group. This finding was masked in the univariate analysis.

After adjusting for the other variables in the multivariate model, adults with diagnosed type 2 diabetes who were in the very low and low morbidity groups were no longer less likely to be in the high adherence group than are those in the medium morbidity group. This was a dramatic change from the univariate model, which placed them at 59.1% and 35.7% less likely to be in the high adherence group. Adults in the high or very high morbidity groups, however, remained more likely to be in the high adherence category (i.e., 54.2% and 98.4%, respectively compared to 54.8% and 100.6% in the univariate model).

Adults with diagnosed type 2 diabetes with no diabetes disease-specific complications continued to be considerably less likely (37.8% compared to 59.4% in the univariate model) to be in the high adherence group than the reference group (i.e., those who had one or more intermediate complications). On the other hand, no significant differences existed between adults with one or more minor or major complications and the reference group with respect to the likelihood of being in the high adherence category.

The LHA of Surrey served as the reference group for location. In the multivariate model, individuals living in the LHAs of South Surrey/White Rock, Burnaby and Langley, were more likely to be in the high adherence group than individuals in the reference group. Individuals living in the LHA of New Westminster were no longer distinct from the reference group of Surrey. Individuals living in the LHAs of Abbotsford, Maple Ridge and Mission remained less likely to be in the high adherence group than the reference group.

The overall final model explained a significant proportion of the variation in the probability of being in the high adherence group with a Chi-square test statistic of 1,409.9 (47 *df*) which corresponded to a *p*-value of less than 0.001. The Nagelkerke R Square was 0.092, indicating that 9.2% of the total variance was explained by the model.

The goodness of fit of the multivariate model was assessed using the Hosmer & Lemeshow GOF test. The Hosmer & Lemeshow statistic was 5.7 with 8 *df* which was not statistically significant ($p = 0.677$) indicating that the model was an adequate fit for the observed data.

In summary, the results of the statistical analysis indicated that, after adjusting for numerous covariates and interactions, a number of patient characteristics predicted whether an individual was more or less likely to be in the high or low adherence group. As anticipated, the

multivariate analysis strengthened certain findings highlighting the important contribution that patient characteristics have on long-term adherence to clinical procedures in the ongoing evaluation and treatment of diabetes. Thus, high adherence was most typical of females, older individuals and patients with a high to very high level of co-morbidity. High adherence was also common among people living in the LHA's of South Surrey/White Rock, Burnaby and Langley. In contrast, low adherence was typical of males, younger individuals, those in the lowest SES category, those with no diabetes disease-specific complications and those living in the LHAs of Mission, Maple Ridge and Abbotsford.

4.6 Description of Resource Use Variables

4.6.1 Overview of Resource Use Variables

In addition to assessing the influence of patient characteristics on adherence to recommended tests and procedures, a second goal of this study was to uncover the influence of patient characteristics on the utilization of health care services. Table 4-28 provides a summary of the proportion of adults with diagnosed type 2 diabetes with high utilization of health care services (***see Appendix D for a detailed description of each resource use variable***). The comparison was based on the average annual costs for visits to a general practitioner, visits to a specialist physician and treatment in acute care.

Prior to adjusting for covariates, the preliminary findings of the descriptive analysis revealed some interesting patterns in the seven patient characteristics that were examined. These variables were adherence, gender, age, socio-economic status, morbidity, disease-specific severity and patient residence.

Table 4-28 Proportion of Adults with Diagnosed Type 2 Diabetes
With High Utilization of Average Annual GP, Specialist Physician, Acute Care and Total Costs

	GP Dollars			Specialist Dollars			Acute Care Dollars			Total Dollars		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	19.9%	19.4%	20.5%	20.0%	19.5%	20.6%	20.0%	19.5%	20.6%	20.0%	19.5%	20.6%
By Level of Adherence												
Low	14.5%	13.6%	15.5%	11.2%	10.4%	12.1%	17.1%	16.1%	18.2%	16.5%	15.5%	17.6%
Medium	20.5%	19.7%	21.3%	18.9%	18.1%	19.7%	20.0%	19.3%	20.9%	20.9%	20.1%	21.7%
Hiigh	23.9%	22.8%	25.1%	29.8%	28.6%	31.0%	20.9%	19.8%	21.9%	21.5%	20.5%	22.6%
By Sex												
Female	23.7%	22.9%	24.7%	20.6%	19.9%	21.5%	19.7%	18.9%	20.5%	19.7%	18.9%	20.5%
Male	16.8%	16.1%	17.5%	19.4%	18.7%	20.2%	20.3%	19.5%	21.0%	20.2%	19.5%	21.0%
By Age												
30-39	18.1%	16.0%	20.6%	19.6%	17.4%	22.1%	10.1%	8.6%	12.2%	10.5%	8.9%	12.5%
40-49	16.4%	15.0%	17.8%	16.4%	15.0%	17.8%	10.0%	9.0%	11.2%	10.5%	9.4%	11.7%
50-59	16.6%	15.7%	17.7%	19.1%	18.0%	20.2%	14.4%	13.4%	15.4%	14.8%	13.9%	15.9%
60-69	17.7%	16.7%	18.6%	19.9%	19.0%	21.0%	20.5%	19.6%	21.6%	20.0%	19.0%	21.0%
70-79	28.4%	27.2%	29.6%	22.9%	21.8%	24.1%	32.5%	31.2%	33.8%	32.2%	31.0%	33.5%
By Socio-Economic Status												
Quintile 1 (Low)	27.4%	26.1%	28.8%	21.9%	20.7%	23.2%	22.3%	21.1%	23.7%	23.1%	21.9%	24.5%
Quintile 2	21.1%	19.9%	22.4%	20.1%	18.9%	21.3%	20.3%	19.1%	21.5%	20.1%	18.9%	21.3%
Quintile 3	18.9%	17.8%	20.1%	18.0%	17.0%	19.2%	18.2%	17.2%	19.4%	18.0%	17.0%	19.2%
Quintile 4	16.5%	15.4%	17.7%	19.8%	18.7%	21.1%	19.4%	18.3%	20.7%	19.2%	18.0%	20.4%
Quintile 5 (High)	13.3%	12.1%	14.7%	21.0%	19.6%	22.6%	19.0%	17.6%	20.5%	18.8%	17.4%	20.3%
By Morbidity												
Very Low	0.0%			0.0%			2.4%	1.2%	4.7%	1.8%	0.8%	3.9%
Low	1.2%	0.8%	1.7%	1.6%	1.2%	2.2%	4.1%	3.3%	5.0%	3.3%	2.7%	4.2%
Medium	4.3%	3.7%	4.9%	4.8%	4.2%	5.4%	6.2%	5.6%	7.0%	5.5%	4.9%	6.2%
High	13.4%	12.7%	14.2%	15.9%	15.1%	16.8%	17.7%	16.9%	18.6%	17.1%	16.3%	18.0%
Very High	49.4%	48.1%	50.8%	45.2%	44.0%	46.6%	41.3%	40.1%	42.7%	42.9%	41.7%	44.3%
By Disease-Specific Severity Index												
No Complications	10.4%	9.6%	11.1%	10.8%	10.0%	11.6%	10.0%	9.3%	10.8%	9.6%	8.9%	10.3%
1 or More Minor Complications	20.1%	19.2%	21.1%	18.2%	17.3%	19.1%	18.6%	17.7%	19.5%	18.7%	17.9%	19.7%
1 or More Intermediate Complications	27.5%	26.5%	28.7%	28.2%	27.1%	29.3%	28.1%	27.1%	29.3%	28.4%	27.4%	29.6%
1 Major Complication	32.5%	27.8%	37.7%	42.9%	37.7%	48.2%	44.4%	39.2%	49.7%	44.1%	38.9%	49.4%
2 or More Major Complications	48.2%	42.7%	54.2%	60.7%	55.3%	66.5%	69.0%	63.5%	74.2%	66.9%	61.2%	72.1%
By Patient Residence												
LHA 202 - S. Surrey / WR	17.1%	14.9%	19.5%	20.3%	18.0%	22.9%	22.6%	20.2%	25.3%	22.2%	19.8%	24.9%
LHA 201 - Surrey	23.9%	22.7%	25.1%	21.0%	19.9%	22.2%	17.9%	16.9%	19.0%	18.6%	17.5%	19.7%
LHA 076 - Agassiz-Harrison	18.7%	12.8%	26.5%	12.2%	7.5%	19.2%	23.6%	17.0%	31.8%	22.0%	15.6%	30.1%
LHA 075 - Mission	23.0%	19.9%	26.8%	14.3%	11.6%	17.4%	21.3%	18.2%	25.0%	21.3%	18.1%	24.8%
LHA 043 - Coquitlam	15.0%	13.6%	16.5%	19.4%	17.9%	21.0%	10.6%	17.3%	20.4%	18.2%	16.8%	19.8%
LHA 042 - Maple Ridge	22.8%	20.4%	25.5%	17.5%	15.4%	19.9%	22.3%	19.9%	25.0%	22.7%	20.3%	25.4%
LHA 041 - Burnaby	17.0%	15.8%	18.4%	21.9%	20.6%	23.4%	16.5%	15.3%	17.9%	16.8%	15.5%	18.1%
LHA 040 - New Westminster	20.3%	17.8%	23.0%	24.0%	21.4%	26.9%	23.8%	21.2%	26.7%	24.1%	21.5%	27.0%
LHA 037 - Delta	19.4%	17.5%	21.6%	23.4%	15.1%	19.0%	18.9%	16.7%	21.1%	19.3%	17.3%	21.5%
LHA 035 - Langley	16.0%	14.3%	17.9%	18.8%	16.9%	20.8%	23.0%	21.1%	25.2%	22.1%	20.1%	24.2%
LHA 034 - Abbotsford	22.5%	20.7%	24.5%	17.1%	15.5%	18.9%	22.9%	21.1%	25.0%	22.4%	20.6%	24.4%
LHA 033 - Chilliwack	20.4%	18.1%	22.9%	15.6%	13.6%	18.0%	23.7%	21.3%	26.4%	22.9%	20.5%	25.5%
LHA 032 - Hope	36.1%	28.4%	44.5%	18.0%	12.4%	25.5%	32.3%	25.0%	40.7%	30.1%	22.9%	38.3%

Adults with diagnosed type 2 diabetes who are in the low adherence group are also more likely to be in the low utilization category of GP, specialist, acute care and total dollars than individuals in the medium or high adherence groups.

The only significant gender differences appear in the use of GP dollars, with females (23.7%, CI of 22.9%, 24.7%) significantly more likely to be in the high utilization category than males (16.8%, CI of 16.1%, 17.5%).

Individuals aged 70-79 are more likely to be in the high utilization category for GP, specialist physician, acute care and total cost categories compared to younger individuals. There appears to be a clear trend in the probability of being in the high utilization of acute care cost category with increasing age. Given that acute care costs tend to dominate total costs, this trend is also seen in the total cost area.

Individuals in the lowest socio-economic status (SES) category (quintile 1) are more likely to be in the high utilization of GP, acute care and total costs categories, but not specialist costs, than individuals in the higher SES categories.

Individuals living in the local health area (LHA) of Hope have the highest probability (30.1%; 95% CI of 22.9%, 38.3%) of being in the high utilization of total cost category. Thirty six percent of adults with diagnosed type 2 diabetes living within the geographic boundaries of the Hope LHA are in the high utilization of GP costs and 32.3% are in the high utilization of acute care cost category. The proportion of individuals in the high utilization of specialist physician cost category, on the other hand, is lower than average.

Individuals living in the LHA of Coquitlam are consistently below the average in the proportion of individuals in the high utilization category for all services. This is the only LHA in which this occurs. On the other hand, individuals living in the LHA of New Westminster are consistently *above* the average in the proportion of individuals in the high utilization category for all services. Again, this is the only LHA in which this occurs.

Table 4-29 provides an overall summary of resource use by adults with diagnosed type 2 diabetes who live in the geographic boundaries of the Fraser Health Authority. On average over the five year period from April 1, 1996 to March 31, 2001, each individual used 1.62 acute care inpatient days per year at an estimated cost of $1,148. In addition, they utilized an average of $124 in surgical day care services per person per year. The average number of physician visits per person per year consisted of 9.74 GP visits at a cost of $302 and 2.88 specialist physician visits at a cost of $189. Average annual costs per person were $1,762 consisting of $491 (28%) in physician costs and $1,272 (72%) in acute care costs.

Table 4-29 Per Capita Mean Utilization of Hospital and MSP Services
By Adults with Diagnosed Type 2 Diabetes

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Acute Care																		
Discharges	0.19	0.18	0.20	0.21	0.20	0.22	0.22	0.21	0.23	0.22	0.21	0.23	0.23	0.22	0.24	0.21	0.21	0.22
Patient Days	1.25	1.16	1.35	1.45	1.35	1.56	1.49	1.38	1.60	1.77	1.64	1.90	2.13	1.97	2.29	1.62	1.55	1.69
Estimated Cost																		
Acute Care Inpatient	$ 906	846	967	1,048	980	1,117	1,108	1,036	1,182	1,216	1,144	1,289	1,459	1,358	1,561	1,148	1,107	1,189
Surgical Day Care	$ 107	101	112	110	105	115	116	110	121	142	136	149	145	139	152	124	121	127
Sub-Total	$ 1,013	951	1,074	1,158	1,089	1,228	1,224	1,151	1,298	1,358	1,285	1,432	1,605	1,502	1,707	1,272	1,230	1,313
Medical Service Plan																		
GP Visits	9.05	8.95	9.16	9.83	9.73	9.94	9.63	9.52	9.73	10.60	9.96	10.17	10.11	10.00	10.22	9.74	9.65	9.83
GP Expenditures	$ 272	268	275	303	299	306	297	294	301	310	307	314	327	323	331	302	299	304
Specialist Visits	2.55	2.49	2.61	2.87	2.81	2.94	2.85	2.79	2.92	3.00	2.93	3.06	3.10	3.03	3.17	2.88	2.83	2.92
Specialist Expenditures	$ 164	160	169	189	185	194	187	183	192	194	190	199	209	204	213	189	186	192
Sub-Total	$ 436	430	442	492	485	498	485	478	491	505	498	511	535	528	543	491	485	496
Total Cost	$ 1,449	1,384	1,514	1,650	1,576	1,723	1,708	1,632	1,787	1,863	1,786	1,940	2,140	2,033	2,247	1,762	1,718	1,807
Annual % Increase				*13.9%*			*3.6%*			*9.0%*			*14.9%*					

Note: N=20,228
Costs are in constant 2000 Canadian dollars

Between 1996/97 and 2000/01, the annual utilization of all resources increased significantly. Mean acute care costs increased from $1,013 in 1996/97 to $1,605 in 2000/01. Mean physician costs increased from $436 in 1996/97 to $535 in 2000/01. Mean total costs increased from $1,449 in 1996/97 to $2,140 in 2000/01. On a year over year basis, total costs (in constant 2000/01 dollars) per person increased by 13.9% from 1996/97 to 1997/98 and by 3.6%, 9.0% and 14.9%, respectively, in each of the following years.

It should be remembered that this is a cohort study in which the same subjects were followed during the five years of the study period. As such, they would be five years older on March 31, 2001 than on April 1, 1996. In addition, since incident cases are not included in the study population, the subjects would also have had type 2 diabetes for an additional five years by the end of the study period compared to the beginning of the study period.

4.6.2 Mean Annual per Capita Costs by Age, Morbidity and Gender

Tables 4-30 to 4-32 provide information on mean annual per capita costs by age, morbidity and gender. Overall, mean annual per capita costs increase significantly by age from age 40 and up. The mean annual per capita costs increase from $1,183 for 40-49 year olds to $1,367 for 50-59 year olds to $1,743 for 60-69 year olds and to $2,611 for 70-79 year olds. The mean annual per capita costs for 30-39 year olds vary significantly by gender, with costs substantially higher for females ($1,504) compared to males ($949). This is the only age-related significant difference between the sexes in mean annual per capita costs and may be explained by differences in resource use associated with childbearing in this age group.

Overall, mean annual per capita costs increase significantly by level of morbidity. Individuals in the very low morbidity group had mean annual per capita costs of $259. These costs increase to $473 for those in the low morbidity group, $727 in the medium morbidity group, $1,498 in the high morbidity group and $3,529 in the very high morbidity group.

There were no significant gender differences in mean annual per capita costs by morbidity level with the exception of those individuals in the very high morbidity group. In this group, males on average had higher costs than females (i.e., $3749 compared to $3,316).

Table 4-30 Adults with Diagnosed Type 2 Diabetes
Mean Annual Per Capita Costs
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	258	143	373	275	218	332	540	431	649	904	766	1,041	2,756	2,075	3,437	**1,222**	**1,052**	**1,392**
40-49	242	145	339	324	270	377	600	502	699	952	863	1,042	2,743	2,375	3,111	**1,183**	**1,083**	**1,284**
50-59	266	182	350	420	354	486	609	548	670	1,231	1,135	1,328	2,933	2,697	3,168	**1,367**	**1,293**	**1,440**
60-69	332	227	437	469	412	526	720	650	789	1,540	1,442	1,637	3,377	3,167	3,586	**1,743**	**1,667**	**1,820**
70-79	465	283	647	778	605	951	1061	939	1,183	2,055	1,922	2,189	4,492	4,244	4,740	**2,611**	**2,500**	**2,721**
Total	**312**	**259**	**365**	**473**	**432**	**515**	**727**	**687**	**768**	**1,498**	**1,443**	**1,552**	**3,529**	**3,403**	**3,655**	**1,762**	**1,718**	**1,807**

Table 4-31 Females with Diagnosed Type 2 Diabetes
Mean Annual Per Capita Costs
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	454	---	4,065	314	206	422	662	487	836	1,062	811	1,314	2,693	1,690	3,696	**1,504**	**1,207**	**1,801**
40-49	180	89	271	381	236	526	565	444	686	918	797	1,039	2,581	2,129	3,032	**1,272**	**1,122**	**1,423**
50-59	301	117	486	417	276	557	661	537	785	1,099	963	1,235	2,479	2,175	2,783	**1,348**	**1,235**	**1,461**
60-69	186	158	214	383	327	438	648	567	729	1,472	1,315	1,630	3,180	2,887	3,473	**1,723**	**1,605**	**1,840**
70-79	594	257	932	831	490	1,171	963	800	1,126	2,034	1,843	2,226	4,368	4,030	4,707	**2,613**	**2,455**	**2,771**
Total	**313**	**220**	**406**	**488**	**399**	**576**	**715**	**655**	**775**	**1,466**	**1,382**	**1,549**	**3,316**	**3,144**	**3,488**	**1,815**	**1,747**	**1,884**

Table 4-32 Males with Diagnosed Type 2 Diabetes
Mean Annual Per Capita Costs
By Age and Level of Morbidity

	Level of Morbidity																	
	Very Low			Low			Medium			High			Very High			Total		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
By Age *(in year 3)*																		
30-39	230	123	337	260	192	329	472	332	612	769	632	906	2,853	2,045	3,660	**949**	**779**	**1,119**
40-49	262	136	387	302	251	353	623	482	765	981	851	1,111	2,936	2,333	3,539	**1,114**	**979**	**1,250**
50-59	256	159	353	421	348	495	577	516	639	1,335	1,200	1,470	3,429	3,068	3,789	**1,384**	**1,286**	**1,481**
60-69	422	255	588	525	438	611	757	656	859	1,601	1,479	1,722	3,559	3,257	3,860	**1,758**	**1,657**	**1,859**
70-79	350	168	532	710	562	858	1,155	974	1,337	2,087	1,900	2,274	4,598	4,243	4,953	**2,601**	**2,448**	**2,754**
Total	**313**	**248**	**378**	**461**	**419**	**503**	**733**	**679**	**787**	**1,529**	**1,457**	**1,601**	**3,749**	**3,566**	**3,932**	**1,714**	**1,656**	**1,773**

In the next three sections, the relationship between patient characteristics and three levels of resource use (i.e., total physician costs, total acute care costs and total costs) will be assessed using both univariate and multivariate logistic regression.

4.7 Univariate Logistic Regression Models for Average Annual Total Physician Costs

Table 4-33 provides the results of the univariate logistic regression models comparing high versus low utilization of average annual total physician costs during the five year study period (April 1, 1996 to March 31, 2001). Which patient characteristics had a significant effect on whether or not they were in the high versus low total physician cost category?

Patients in the low adherence category were 41.2% less likely to be in the high resource use group while adults in the high adherence category were 54% *more* likely to be in the high resource use category compared to adults in the medium adherence category (i.e., the reference group). The independent variable of adherence accounted for 2.9% of the variance (Nagelkerke R Square of 0.029) in the dependent variable of low or high average annual resource use.

In the absence of adjustment for other covariates in the model, females were 25.1% more likely to be in the high resource use category than males (the reference group). The independent variable of gender accounted for 0.5% of the variance in the dependent variable of low or high resource use.

With respect to age, the only group more likely to be in the high resource use group compared to the reference group (i.e., adults aged 50-59) was elderly individuals aged 70-79. The independent variable of age accounted for 1.3% of the variance in the dependent variable of low or high resource use.

Individuals in the lowest two socio-economic status (SES) quintiles were more likely to be in the high resource use group than those in the middle quintile (i.e., 49.5% for quintile 1 and 16.9% for quintile 2). The independent variable of SES accounted for 0.8% of the variance in the dependent variable of low or high resource use.

Table 4-33 Univariate Logistic Regression Models for
High vs. Low Utilization of Average Annual Total Physician Costs

	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper	-2 log likelihood	Model X_2	df	*p* -value	Nagelkerke R Square	Selection
By Level of Adherence													
Low	-0.531	0.049	115.2	< 0.001	0.588	0.534	0.648	19,846.0	374.4	2	<0.001	0.029	Yes
Medium	*******												
High	0.432	0.04	119.3	< 0.001	1.540	1.426	1.665						
By Sex													
Female	0.293	0.035	69.0	< 0.001	1.340	1.251	1.436	20,115.8	69.0	1	<0.001	0.005	Yes
Male	*******												
By Age *(in Year 3)*													
30-39	0.025	0.087	0.1	0.769	1.026	0.865	1.216	20,054.3	166.1	4	<0.001	0.013	Yes
40-49	-0.124	0.063	3.9	0.050	0.883	0.780	1.000						
50-59	*******												
60-69	0.051	0.049	1.1	0.295	1.053	0.956	1.159						
70-79	0.490	0.049	101.4	< 0.001	1.632	1.484	1.795						
By Socio-Economic Status (in Year 3)													
Quintile 1 (Low)	0.402	0.053	58.4	< 0.001	1.495	1.348	1.657	19,712.4	99.0	4	<0.001	0.008	Yes
Quintile 2	0.156	0.053	8.6	0.003	1.169	1.053	1.298						
Quintile 3	*******												
Quintile 4	-0.032	0.056	0.3	0.569	0.969	0.869	1.080						
Quintile 5 (High)	-0.085	0.064	1.8	0.184	0.919	0.811	1.041						
By Morbidity													
Very Low	-17.680	2,199.3	0.0	0.994	0.368	0.000	0.000	14,718.1	5,313.4	4	<0.001	0.368	Yes
Low	-1.521	0.283	29.0	< 0.001	0.218	0.126	0.380						
Medium	*******												
High	1.571	0.096	267.8	< 0.001	4.810	3.985	5.806						
Very High	3.602	0.093	1,492.4	< 0.001	36.670	30.545	44.022						
By Disease-Specific Severity Index													
No Complications	-1.371	0.051	723.0	< 0.001	0.254	0.230	0.280	19,120.5	1,099.9	4	<0.001	0.084	Yes
1 or More Minor Comp.	-0.583	0.041	197.9	< 0.001	0.558	0.515	0.606						
1 or More Intermediate Comp.	*******												
1 Major Comp.	0.403	0.115	12.2	< 0.001	1.497	1.194	1.877						
2 or More Major Comp.	1.256	0.124	102.9	< 0.001	3.513	2.755	4.478						
By Patient Residence (in Year 3)													
LHA 202 - S. Surrey / WR	-0.202	0.086	5.5	0.019	0.817	0.690	0.968	20,156.9	63.5	12	<0.001	0.005	Yes
LHA 201 - Surrey	*******												
LHA 076 - Agassiz-Harrison	-0.460	0.252	3.3	0.068	0.631	0.385	1.034						
LHA 075 - Mission	-0.102	0.110	0.9	0.352	0.903	0.728	1.120						
LHA 043 - Coquitlam	-0.348	0.064	29.5	< 0.001	0.706	0.623	0.801						
LHA 042 - Maple Ridge	-0.118	0.084	2.0	0.158	0.889	0.754	1.047						
LHA 041 - Burnaby	-0.216	0.056	14.7	< 0.001	0.806	0.721	0.900						
LHA 040 - New Westminster	0.008	0.087	0.0	0.922	1.008	0.851	1.195						
LHA 037 - Delta	-0.005	0.073	0.0	0.950	0.995	0.863	1.148						
LHA 035 - Langley	-0.309	0.075	17.1	< 0.001	0.734	0.634	0.850						
LHA 034 - Abbotsford	-0.239	0.069	11.9	0.001	0.788	0.688	0.902						
LHA 033 - Chilliwack	-0.249	0.086	8.4	0.004	0.779	0.658	0.923						
LHA 032 - Hope	0.396	0.192	4.3	0.039	1.486	1.020	2.166						

*Notes: ******* Reference Category*

Patients who were in the low morbidity group were considerably less likely (78.2%) to be in the high resource use category than the reference group (i.e., those with medium morbidity). On the other hand, adults in the high or very high morbidity groups were much more likely to be in the high resource use category (i.e., 4.8 times and 36.7 times, respectively). The independent variable of morbidity accounted for 36.8% of the variance in the dependent variable of low or high physician resource use.

Patients with no complications or just one or more minor complications were also considerably less likely (74.6% and 44.2%, respectively) to be in the high resource use group than the reference group (i.e., those with one or more intermediate complications). Not surprisingly, adults with one major complication or two or more major complications were 1.5 times and 3.5 times, respectively, more likely to be in the high resource use category. The independent variable of disease-specific severity index accounted for 8.4% of the variance in the dependent variable of low or high resource use.

Adults with diagnosed type 2 diabetes living in certain LHAs varied more from the reference group (i.e., those living in Surrey) in terms of likelihood of being high resource users. Before adjusting for covariates, only individuals living in the LHA of Hope were more likely (48.6%) to be in the high resource use group than the reference group. Adults living in the LHAs of Coquitlam (29.4%), Langley (26.6%), Chilliwack (22.1%), Abbotsford (21.2%), Burnaby (19.4%) and South Surrey / White Rock (18.3%) are all less likely to be in the high resource use group than the reference group. The independent variable of patient residence accounted for 0.5% of the variance in the dependent variable of low or high resource use.

4.8 Multivariate Logistic Regression Model Average Annual Total Physician Costs

4.8.1 Development of a Reduced Main Effects Model for Physician Costs

As noted in table 4-33, the seven independent variables assessed in the univariate analysis were all selected for inclusion in the multivariate model based on a *p*-value of less than 0.001. The seven patient characteristics were entered into the Binary Logistic Regression function of SPSS based on the explanatory power of the variable. Thus the variable morbidity was entered first, followed by disease-specific severity index, adherence, age, socio-economic status, patient residence and gender. Once all of the variables were in the model (the 'full model'), each

variable was sequentially removed in reverse order to assess the impact of the exclusion of each variable from the full model. The results are provided in table 4-34.

Table 4-34 Development and Testing of a Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Physician Costs

	Intermediate Models						Full Model	Assessing the Impact of Removing Individual Variables						
By Level of Adherence			***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***
Low			0.871	0.864	0.843	0.834	0.834	0.664	0.804		0.838	0.852	0.843	0.834
Medium	*******													
High			1.339	1.345	1.351	1.372	1.373	1.440	1.393		1.366	1.367	1.352	1.372
By Sex							***0.686***	***<0.001***	***0.731***	***0.841***	***0.866***	***0.813***	***0.718***	
Female							0.983	1.183	0.986	0.992	0.993	0.010	0.985	
Male	*******													
By Age *(in Year 3)*				***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***
30-39				0.993	0.957	0.932	0.932	1.219	0.889	0.894		0.964	0.957	0.932
40-49				0.937	0.930	0.925	0.925	1.002	0.889	0.910		0.931	0.930	0.925
50-59	*******													
60-69				0.852	0.847	0.860	0.860	0.895	0.886	0.871		0.865	0.848	0.860
70-79				1.176	1.158	1.185	1.191	1.278	1.244	1.185		1.213	1.164	1.185
By Socio-Economic Status (in Year 3)					***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Quintile 1 (Low)					1.349	1.412	1.411	1.507	1.408	1.398	1.432		1.348	1.412
Quintile 2					1.127	1.177	1.176	1.213	1.169	1.176	1.182		1.125	1.177
Quintile 3	*******													
Quintile 4					0.936	1.003	1.003	1.032	1.004	1.013	1.003		0.936	1.003
Quintile 5 (High)					0.956	0.974	0.976	0.958	0.975	0.995	0.975		0.958	0.974
By Morbidity	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Very Low	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
Low	0.218	0.232	0.238	0.239	0.242	0.244	0.244		0.233	0.237	0.243	0.241	0.242	0.244
Medium	*******													
High	4.810	4.428	4.305	4.276	4.230	4.212	4.215		4.476	4.360	4.244	4.254	4.232	4.212
Very High	36.670	31.442	30.532	30.350	29.641	29.765	29.781		33.496	30.819	29.916	30.316	29.639	29.765
By Disease-Specific Severity Index		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
No Complications		0.580	0.612	0.629	0.630	0.627	0.629	0.297		0.596	0.605	0.629	0.631	0.627
1 or More Minor Comp.		0.926	0.961	0.987	0.979	0.973	0.976	0.610		0.936	0.948	0.980	0.982	0.973
1 or More Intermediate Comp.	*******													
1 Major Comp.		1.183	1.193	1.201	1.192	1.200	1.212	1.513		1.203	1.195	1.224	1.203	1.200
2 or More Major Comp.		2.480	2.510	2.569	2.546	2.582	2.566	3.592		2.543	2.487	2.599	2.531	2.582
By Patient Residence (in Year 3)						***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***
LHA 202 - S. Surrey / WR						0.853	0.853	0.869	0.837	0.875	0.901	0.755		0.853
LHA 201 - Surrey	*******													
LHA 076 - Agassiz-Harrison						0.077	0.077	0.143	0.075	0.083	0.075	0.537		0.077
LHA 075 - Mission						1.001	1.013	0.991	0.986	0.980	1.032	1.023		1.001
LHA 043 - Coquitlam						0.881	0.880	0.752	0.890	0.879	0.889	0.806		0.881
LHA 042 - Maple Ridge						1.028	1.026	0.976	1.037	1.004	1.039	0.979		1.028
LHA 041 - Burnaby						0.870	0.868	0.779	0.859	0.902	0.879	0.842		0.870
LHA 040 - New Westminster						1.044	1.048	0.893	1.071	1.057	1.068	1.028		1.044
LHA 037 - Delta						1.291	1.291	1.152	1.294	1.290	1.305	1.137		1.291
LHA 035 - Langley						0.653	0.651	0.653	0.667	0.676	0.668	0.613		0.653
LHA 034 - Abbotsford						0.887	0.885	0.826	0.872	0.860	0.905	0.854		0.887
LHA 033 - Chilliwack						0.701	0.700	0.678	0.719	0.705	0.715	0.691		0.701
LHA 032 - Hope						1.397	1.431	1.803	1.406	1.410	1.498	1.232		1.397
-2 log likelihood	14,718	14,561	14,500	14,463	14,151	14,082	14,064	18,266	14,190	14,138	14,101	14,376	14,133	14,082
Likelihood Ratio Test X^2	5,313	5,470	5,532	5,569	5,472	5,541	5,529	1,516	5,403	5,455	5,492	5,620	5,459	5,541
Degrees of Freedom	4	8	10	14	18	30	31	27	27	29	27	27	19	30
p - value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nagelkerke R Square	0.368	0.378	0.381	0.384	0.385	0.389	0.389	0.117	0.381	0.384	0.386	0.387	0.384	0.389
Hosmer & Lemeshow GOF	1.000	0.128	0.387	0.227	0.051	0.109	0.047	0.113	0.321	0.201	0.142	0.844	0.028	0.109
Change in -2 Log Likelihood if Variable Removed								4,018.0	126.5	74.5	37.2	41.1	69.8	0.2
p - value of Change								< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.069

*Notes: ******* Reference Category*

Significant Odds Ratios (OR) are highlighted in yellow.

The p-value for each (grouped) variable is provided in ***bolded italics*** *above the first OR value for that group.*

Table 4-35 presents the detailed results of the main effects model. Six of the seven patient characteristics, excluding gender, were significant predictors of the probability of being in the high utilization category.

Table 4-35 Main Effects Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Physician Costs

	p-value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Level of Adherence	***<0.001***							
Low		-0.181	0.059	9.3	0.002	0.834	0.742	0.937
Medium		*******						
High		0.316	0.048	44.3	< 0.001	1.372	1.250	1.506
By Age *(in Year 3)*	***<0.001***							
30-39		-0.070	0.113	0.4	0.536	0.932	0.747	1.164
40-49		-0.078	0.076	1.0	0.306	0.925	0.798	1.074
50-59		*******						
60-69		-0.151	0.059	6.6	0.010	0.860	0.766	0.965
70-79		0.169	0.060	8.1	0.004	1.185	1.054	1.331
By Socio-Economic Status (in Year 3)	***<0.001***							
Quintile 1 (Low)		0.345	0.064	28.8	< 0.001	1.412	1.245	1.602
Quintile 2		0.163	0.064	6.4	0.011	1.177	1.038	1.334
Quintile 3		*******						
Quintile 4		0.003	0.067	0.0	0.967	1.003	0.879	1.143
Quintile 5 (High)		-0.027	0.078	0.1	0.731	0.974	0.836	1.134
By Morbidity	***<0.001***							
Very Low		-17.480	2,206.9	0.0	0.994	0.000	0.000	.
Low		-1.412	0.283	24.9	< 0.001	0.244	0.140	0.424
Medium		*******						
High		1.438	0.098	217.4	< 0.001	4.212	3.479	5.099
Very High		3.393	0.095	1,265.0	< 0.001	29.765	24.689	35.885
By Disease-Specific Severity Index	***<0.001***							
No Complications		-0.467	0.062	56.6	< 0.001	0.627	0.555	0.708
1 or More Minor Comp.		-0.027	0.050	0.3	0.584	0.973	0.882	1.073
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.183	0.134	1.9	0.172	1.200	0.924	1.560
2 or More Major Comp.		0.948	0.144	43.6	< 0.001	2.582	1.948	3.421
By Patient Residence (in Year 3)	***<0.001***							
LHA 202 - S. Surrey / WR		-0.159	0.106	2.2	0.134	0.853	0.693	1.050
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		-2.561	1.049	6.0	0.015	0.077	0.010	0.603
LHA 075 - Mission		0.001	0.134	0.0	0.991	1.001	0.771	1.301
LHA 043 - Coquitlam		-0.127	0.078	2.6	0.104	0.881	0.756	1.026
LHA 042 - Maple Ridge		0.028	0.103	0.1	0.787	1.028	0.840	1.259
LHA 041 - Burnaby		-0.140	0.068	4.2	0.040	0.870	0.761	0.994
LHA 040 - New Westminster		0.043	0.104	0.2	0.679	1.044	0.851	1.280
LHA 037 - Delta		0.255	0.092	7.8	0.005	1.291	1.079	1.544
LHA 035 - Langley		-0.426	0.090	22.3	< 0.001	0.653	0.547	0.779
LHA 034 - Abbotsford		-0.120	0.083	2.1	0.149	0.887	0.753	1.044
LHA 033 - Chilliwack		-0.356	0.105	11.4	0.001	0.701	0.570	0.861
LHA 032 - Hope		0.334	0.233	2.1	0.152	1.397	0.884	2.206

FITTED MODEL	-2 log likelihood	14,082.0
	Likelihood Ratio Test X^2	5,540.5
	Degrees of Freedom	30
	p - value	<0.001
	Nagelkerke R Square	0.389
	Hosmer & Lemeshow GOF	0.109

*Notes: ******* Reference Category*

4.8.2 Development of a Final Fitted Model for Physician Costs

After the development of the main effects model, all possible two-way interactions were tested individually based on Wald statistics and their *p*-values. All but one potential two-factor term (i.e., adherence by gender) was found to be significant. To assess these potential interactions in the model, the main effects were entered as a block and the potential two-way interactions were included as a second block using the Forward Stepwise (Likelihood Ratio) approach. This analysis identified two two-way interactions that remained significant after adjusting for the other variables in the model; age group by DSS Index (p=0.043) and age group by adherence (p<0.001).

The potential three-way interaction between DSS Index, age and adherence was subsequently tested based on the Wald statistic and its *p*-value and found to be significant. This three-way interaction was included with the two-way interactions in the second block. This analysis indicated that only the original two-way interactions remained significant after adjusting for the other variables in the model.

The interaction between age and adherence is shown on table 4-36 and figure 4-7[13].

[13] The significant interactions are highlighted on table 4-36 and circled on figure 4-7.

Table 4-36: Age by Adherence CrossTab

Low Total Physician Dollar Group

Age	Adherence Low	Medium	High	**Total**
30-39	394	363	127	**884**
40-49	836	1,073	436	**2,345**
50-59	1,235	1,973	944	**4,152**
60-69	1,124	2,434	1,492	**5,050**
70-79	903	1,753	1,104	**3,760**
Total	**4,492**	**7,596**	**4,103**	**16,191**

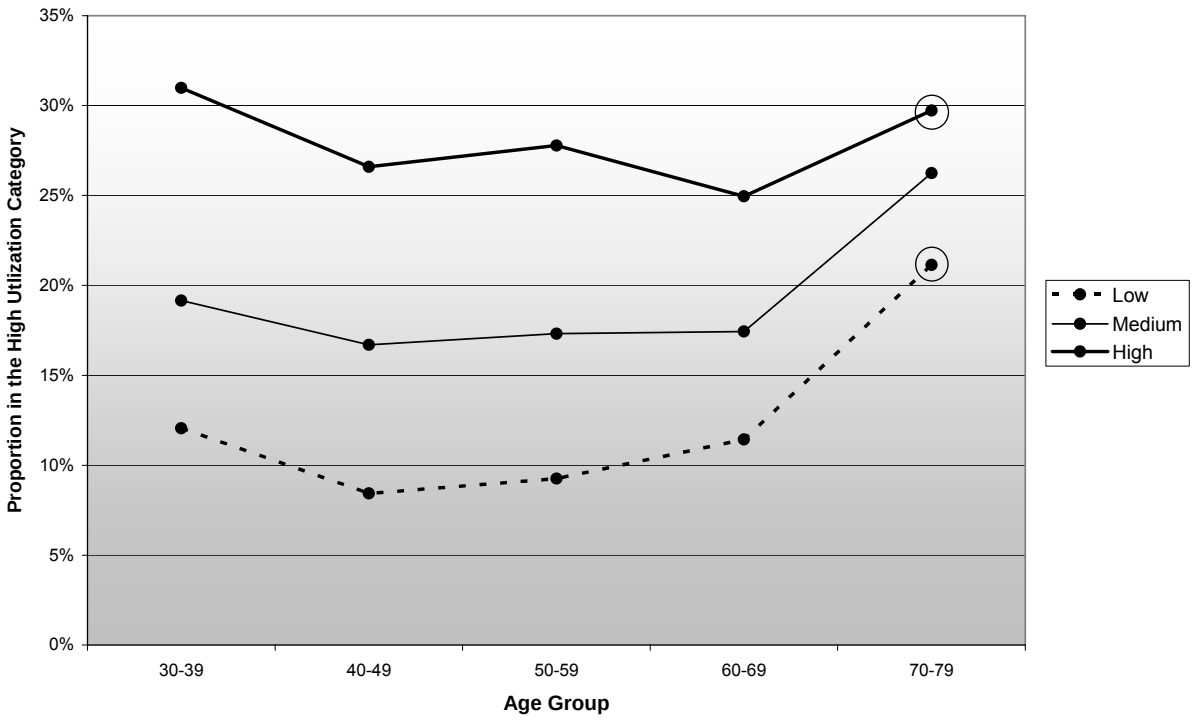
High Total Physician Dollar Group

Age	Adherence Low	Medium	High	**Total**
30-39	54	86	57	**197**
40-49	77	215	158	**450**
50-59	126	413	363	**902**
60-69	145	514	496	**1,155**
70-79	242	624	467	**1,333**
Total	**644**	**1,852**	**1,541**	**4,037**

Percent High Total Physician Dollar Group

Age	Adherence Low	Medium	High	**Total**
30-39	12%	19%	31%	**18%**
40-49	8%	17%	27%	**16%**
50-59	9%	17%	28%	**18%**
60-69	11%	17%	25%	**19%**
70-79	21%	26%	30%	**26%**
Total	**13%**	**20%**	**27%**	**20%**

Figure 4-7 Age by Adherence Interaction



The key interaction identified in the analysis was between 70-79 year olds and the probability of being in the high utilization group (see table 4-36). Specifically, there was an important rise in the probability of individuals aged 70-79 being in the high physician cost category regardless of their level of adherence. In other words, elderly patients with diabetes tended to require extensive services from their physicians, whether or not they received the recommended clinical procedures. More importantly, however, the interaction between age and adherence revealed that individuals aged 70-79 in the low adherence group were 44.3% more likely to be in the high utilization group while those in the high adherence group were 32.1% less likely to be in the high utilization group (see table 4-38). This was an important variation from the general relationship observed between level of adherence and use of physician services. For the entire study population, individuals in the low adherence group were 27.9% less likely to be in the high utilization group while those in the high adherence group were 58.7% more likely to be in the high utilization group (see table 4-38).

The second significant interaction, between age and disease-specific morbidity index, is shown on table 4-37. The significant interactions are highlighted in yellow.

Table 4-37 Age by DSSI CrossTab

Low Total Physician Dollar Group

	DSSI			
Age	None	1+ Minor	1+ Int	**Total**
30-39	574	187	87	**884**
40-49	1,232	723	345	**2,345**
50-59	1,664	1,587	829	**4,152**
60-69	1,441	1,917	1,591	**5,050**
70-79	852	1,236	1,601	**3,760**
Total	**5,763**	**5,650**	**4,453**	**16,191**

High Total Physician Dollar Group

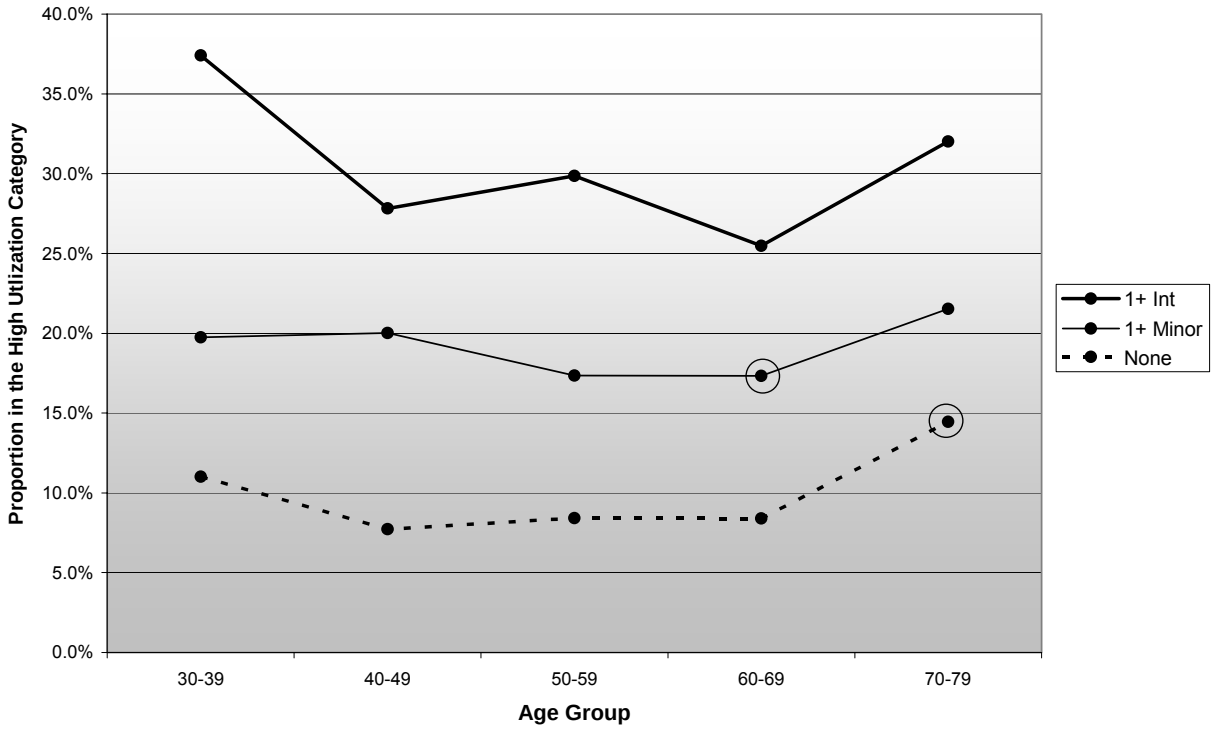
	DSSI			
Age	None	1+ Minor	1+ Int	**Total**
30-39	71	46	52	**197**
40-49	103	181	133	**450**
50-59	153	333	353	**902**
60-69	132	402	544	**1,155**
70-79	144	339	754	**1,333**
Total	**603**	**1,301**	**1,836**	**4,037**

Percent High Total Physician Dollar Group

	DSSI			
Age	None	1+ Minor	1+ Int	**Total**
30-39	11.0%	19.7%	37.4%	**18.2%**
40-49	7.7%	20.0%	27.8%	**16.1%**
50-59	8.4%	17.3%	29.9%	**17.8%**
60-69	8.4%	17.3%	25.5%	**18.6%**
70-79	14.5%	21.5%	32.0%	**26.2%**
Total	**9.5%**	**18.7%**	**29.2%**	**20.0%**

In figure 4-8, the same results are presented graphically but excluding the one major and two or more major complication categories with unstable results caused by small cell sizes. The significant interactions are circled on the graph.

Figure 4-8 Age by DSS Index Interaction



As expected, adults with one or more intermediate disease-specific complications were more likely to be in the high physician utilization category than are those with one or more minor complications. Those with no disease-specific complications were the least likely to be in the high physician utilization group. This relationship was consistent across all age groups.

In figure 4-8, two groups were circled because they were significantly different than the reference group (i.e., those with one or more intermediate complication). In the first of these two groups, the proportion of adults in the high utilization category decreased significantly between 50-59 and 60-69 year olds in the reference group but not in the one or more minor complications

group. In the second of these two groups, the proportion of adults in the high utilization category increased more substantially between 60-69 and 70-79 year olds in the no complications group compared to the reference group (from 8.4% to 14.5% compared to from 25.5% to 32.0%).

The final fitted model, including the main effects and the two significant two-way interactions is shown on table 4-38.

Table 4-38 Final Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Physician Costs

	p-value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Level of Adherence	***<0.001***							
Low		-0.327	0.127	6.6	0.010	0.721	0.563	0.925
Medium		*******						
High		0.462	0.099	21.8	< 0.001	1.587	1.308	1.927
By Age *(in Year 3)*	***<0.001***							
30-39		0.311	0.268	1.3	0.246	1.365	0.807	2.309
40-49		-0.132	0.162	0.7	0.413	0.876	0.638	1.203
50-59		*******						
60-69		-0.378	0.114	11.1	0.001	0.685	0.549	0.856
70-79		0.067	0.110	0.4	0.543	1.069	0.862	1.326
By Socio-Economic Status (in Year 3)	***<0.001***							
Quintile 1 (Low)		0.347	0.065	29.0	< 0.001	1.416	1.247	1.606
Quintile 2		0.170	0.064	7.0	0.008	1.185	1.045	1.344
Quintile 3		*******						
Quintile 4		0.003	0.067	0.0	0.969	1.003	0.879	1.144
Quintile 5 (High)		-0.025	0.078	0.1	0.748	0.975	0.837	1.137
By Morbidity	***<0.001***							
Very Low		-17.450	2,197.2	0.0	0.994	0.000	0.000	.
Low		-1.409	0.283	24.7	< 0.001	0.244	0.140	0.426
Medium		*******						
High		1.430	0.098	214.7	< 0.001	4.178	3.451	5.059
Very High		3.392	0.095	1,261.7	< 0.001	29.729	24.654	35.849
By Disease-Specific Severity Index	***<0.001***							
No Complications		-0.664	0.123	29.2	< 0.001	0.515	0.405	0.655
1 or More Minor Comp.		-0.264	0.104	6.5	0.011	0.768	0.627	0.941
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.035	0.304	0.0	0.907	1.036	0.570	1.881
2 or More Major Comp.		0.683	0.289	5.6	0.018	1.980	1.124	3.486
By Patient Residence (in Year 3)	***<0.001***							
LHA 202 - S. Surrey / WR		-0.147	0.106	1.9	0.168	0.864	0.701	1.064
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		-2.546	1.048	5.9	0.015	0.078	0.010	0.612
LHA 075 - Mission		0.004	0.134	0.0	0.975	1.004	0.772	1.306
LHA 043 - Coquitlam		-0.135	0.078	3.0	0.084	0.874	0.750	1.018
LHA 042 - Maple Ridge		0.023	0.104	0.1	0.823	1.023	0.835	1.254
LHA 041 - Burnaby		-0.140	0.068	4.2	0.041	0.870	0.761	0.994
LHA 040 - New Westminster		0.047	0.104	0.2	0.649	1.049	0.855	1.287
LHA 037 - Delta		0.262	0.092	8.1	0.004	1.300	1.086	1.557
LHA 035 - Langley		-0.426	0.091	22.1	< 0.001	0.653	0.547	0.780
LHA 034 - Abbotsford		-0.126	0.084	2.3	0.133	0.882	0.749	1.039
LHA 033 - Chilliwack		-0.373	0.106	12.5	< 0.001	0.688	0.560	0.847
LHA 032 - Hope		0.338	0.234	2.1	0.149	1.402	0.886	2.217
Age by DSSIndex	***0.043***							
30-39 by No Complications		-0.328	0.304	1.2	0.280	0.720	0.397	1.306
30-39 by 1 or More Minor Comp.		-0.331	0.320	1.1	0.301	0.718	0.384	1.344
30-39 by 1 Major Complication		-0.206	0.584	0.1	0.724	0.814	0.259	2.555
30-39 by 2+ Major Complications		-0.254	0.559	0.2	0.649	0.776	0.259	2.319
40-49 by No Complications		-0.019	0.206	0.0	0.928	0.982	0.655	1.470
40-49 by 1 or More Minor Comp.		0.276	0.186	2.2	0.138	1.318	0.915	1.899
40-49 by 1 Major Complication		0.016	0.503	0.0	0.975	1.016	0.379	2.724
40-49 by 2+ Major Complications		-0.209	0.481	0.2	0.663	0.811	0.316	2.084
60-69 by No Complications		0.295	0.170	3.0	0.082	1.343	0.963	1.873
60-69 by 1 or More Minor Comp.		0.391	0.135	8.4	0.004	1.478	1.134	1.926
60-69 by 1 Major Complication		-0.082	0.398	0.0	0.837	0.921	0.423	2.009
60-69 by 2+ Major Complications		0.661	0.400	2.7	0.098	1.938	0.884	4.245
70-79 by No Complications		0.432	0.171	6.4	0.011	1.540	1.102	2.151
70-79 by 1 or More Minor Comp.		0.202	0.137	2.2	0.141	1.224	0.935	1.601
70-79 by 1 Major Complication		0.440	0.386	1.3	0.254	1.553	0.729	3.308
70-79 by 2+ Major Complications		0.255	0.416	0.4	0.540	1.291	0.571	2.919
Age by Adherence	***<0.001***							
30-39 by Low Adherence		-0.128	0.280	0.2	0.647	0.880	0.509	1.522
40-49 by Low Adherence		-0.018	0.207	0.0	0.929	0.982	0.654	1.474
60-69 by Low Adherence		0.128	0.172	0.6	0.457	1.137	0.811	1.593
70-79 by Low Adherence		0.367	0.165	4.9	0.026	1.443	1.044	1.993
30-39 by High Adherence		-0.155	0.278	0.3	0.577	0.856	0.497	1.476
40-49 by High Adherence		-0.031	0.173	0.0	0.858	0.969	0.690	1.361
60-69 by High Adherence		-0.047	0.129	0.1	0.717	0.954	0.740	1.230
70-79 by High Adherence		-0.387	0.131	8.8	0.003	0.679	0.526	0.877

FITTED MODEL		
	-2 log likelihood	14,050.0
	Likelihood Ratio Test X^2	5,599.4
	Degrees of Freedom	54.0
	p - value	<0.001
	Nagelkerke R Square	0.392
	Hosmer & Lemeshow GOF	0.802

*Notes: ******* Reference Category*

4.8.3 Interpretation of the Final Fitted Model for Physician Costs

After adjusting for the covariates and interactions in the model, patients in the low adherence group had a 27.9% lower probability of being in the high physician resource use group than patients in the medium adherence category. Individuals in the high adherence group, on the other hand, had a 58.7% higher probability of being in the high resource use group than individuals in the medium adherence category. These differences increased from 16.6% and 37.2% (in the univariate model) after adjusting for the covariates in the model.

The increased likelihood of being in the high resource use group associated with high adherence may be due to several reasons. Most probably, the higher costs associated with high adherence are due to more frequent visits to a physician to receive the recommended tests and procedures. We were not able to determine which physician costs were associated specifically with improved adherence to the recommended clinical procedures versus other care provided by physicians. This would be a question for further research.

Adults aged 60-69 were 31.5% less likely to be in the high physician utilization category compared to the reference group of 50-59 year olds. This finding was not expected given that increasing age is generally associated with increased physician utilization. Table 4-39 provides further information on the proportion of individuals in the high vs. low resource use groups by age and physician category (general practitioner, specialist physician and total physician). Based on age category alone, there were no significant differences between the 50-59 and 60-69 year age groups in the proportion of individuals in the high utilization category for either of the three physician categories. Yet after adjusting for the other covariates in the model, adults in the 60-69 year old group were less likely to be in the high utilization category for total physician costs.

One possible explanation for this finding is that individuals aged 50-59 with diagnosed type 2 diabetes have had their diagnosis confirmed for a shorter period of time, on average, than those aged 60-69 and may still be in the process establishing an appropriate treatment protocol for the control of their diabetes resulting in relatively more frequent physician visits. This would assume that establishing a treatment protocol would take some time since newly diagnosed adults were excluded from the study sample.

Table 4-39 Proportion of Adults with Diagnosed Type 2 Diabetes
High vs. Low Utilization of Average Annual Physician Costs

	Total N in Year 3	Low Utilization				High Utilization			
		N	%	95% CI		N	%	95% CI	
By Age *(in Year 3)*				***General Practitioners***					
30-39	1,081	885	81.9%	79.5%	84.0%	196	18.1%	16.0%	20.5%
40-49	2,795	2,337	83.6%	82.2%	84.9%	458	16.4%	15.1%	17.8%
50-59	5,054	4,209	83.3%	82.2%	84.3%	845	16.7%	15.7%	17.8%
60-69	6,205	5,104	82.3%	81.3%	83.2%	1,101	17.7%	16.8%	18.7%
70-79	5,093	3,638	71.4%	70.2%	72.7%	1,455	28.6%	27.3%	29.8%
				Specialist Physicians					
30-39	1,081	869	80.4%	77.9%	82.7%	212	19.6%	17.4%	22.1%
40-49	2,795	2,335	83.5%	82.1%	84.9%	460	16.5%	15.1%	17.9%
50-59	5,054	4,088	80.9%	79.8%	82.0%	966	19.1%	18.1%	20.2%
60-69	6,205	4,963	80.0%	79.0%	81.0%	1,242	20.0%	19.0%	21.0%
70-79	5,093	3,918	76.9%	75.8%	78.1%	1,175	23.1%	21.9%	24.3%
				All Physicians					
30-39	1,081	884	81.8%	79.4%	84.0%	197	18.2%	16.0%	20.6%
40-49	2,795	2,345	83.9%	82.5%	85.2%	450	16.1%	14.8%	17.5%
50-59	5,054	4,152	82.2%	81.1%	83.2%	902	17.8%	16.8%	18.9%
60-69	6,205	5,050	81.4%	80.4%	82.3%	1,155	18.6%	17.7%	19.6%
70-79	5,093	3,760	73.8%	72.6%	75.0%	1,333	26.2%	25.0%	27.4%

As noted previously, the interaction between age and adherence revealed that individuals aged 70-79 in the low adherence group were 44.3% more likely to be in the high utilization group while those in the high adherence group were 32.1% less likely to be in the high utilization group.

Individuals in the lowest two socio-economic status groups were more likely to be in the high resource use group. Individuals in quintile one had a 41.6% higher probability of being in the high resource use group compared to those in the reference group of quintile three.

Individuals in quintile two had a 18.5% higher probability of being in the high resource use group compared to the reference group.

After adjusting for the covariates in the multivariate model, patients who were in the low morbidity group are considerably less likely (75.6%) to be in the high resource use group than are those in the medium morbidity group. Not surprisingly, adults in the high or very high morbidity groups are considerably more likely to be in the high resource use category (4.2 and 29.7 times, respectively).

Patients with no diabetes disease-specific complicating conditions were 48.5% less likely while those with one or minor complicating conditions were 23.2% less likely (OR=0.768) to be in the high resource use group than are those who have one or more intermediate complicating conditions (the reference group). On the other hand, adults with two or more major complicating conditions were 98% more likely to be in the high resource use category.

After adjusting for the covariates in the model, patients living in the LHA of Hope were no longer more likely to be in the high resource use category than the reference group of patients living in Surrey. The LHA of Delta now became the only LHA in which adults had a higher probability (30.0%) of being in the high resource use category compared to the reference group. Individuals living in Langley (34.7%), Chilliwack (31.2%), Burnaby (13.0%) and Agassiz/Harrison (92.2%) were all less likely to be in the high resource use group than individuals in the reference group.

The overall final model accounted for a significant proportion of the variation in the probability of being in the high resource use group with a Chi-square test statistic of 5,599.4 (54 *df*) which corresponds to a *p*-value of less than 0.001. The Nagelkerke R Square was 0.392, indicating that 39.2% of the total variance was explained by the model.

The goodness of fit of the multivariate model was assessed using the Hosmer & Lemeshow GOF test. The Hosmer & Lemeshow statistic was 4.6 with 8 *df* which was not statistically significant ($p = 0.802$) indicating that the model was an adequate fit for the observed data.

In summary, after adjusting for numerous covariates and interactions (i.e. the individual's level of adherence, age, socio-economic status, general morbidity, disease-specific morbidity, geographic location of residence, interactions between age and disease-specific morbidity and age and adherence), a number of patient characteristics predicted whether an individual was more or less likely to be in the high average annual total physician cost group. The populations that were less likely to be in the high physician cost category were:

- those in the low adherence category
- those aged 60-69
- those with a low level of co-morbidity
- those with no or only minor diabetes disease-specific complications, and
- those living in the LHAs of Langley, Chilliwack, Burnaby and Agassiz/Harrison

The populations that were more likely to be in the high physician cost category were:

- adults in the high adherence group
- those in the lowest two SES categories
- those with a high or very high level of co-morbidity
- those with two or more major diabetes disease-specific complications
- those living in the LHA of Delta

4.9 Univariate Logistic Regression Models for Average Annual Total Acute Care Costs

Acute care utilization was defined by average annual costs for treatment in hospital or in surgical day care. Table 4-40 provides the results of the univariate logistic regression models comparing high versus low utilization of acute care services during the five year study period (April 1, 1996 to March 31, 2001). Which patient characteristics had a significant effect on whether or not adults with diagnosed type 2 diabetes were in the high versus low categories for acute care utilization?

Prior to adjusting for covariates, patients in the low adherence category were 22.2% (OR = 0.778) *less* likely to be in the high acute care utilization category compared to adults in the medium adherence category (i.e., the reference group). The independent variable of adherence accounted for 0.3% of the variance (Nagelkerke R Square of .003) in the dependent variable of low or high average annual acute care costs.

In the absence of adjustment for other covariates in the model, there were no significant differences (p=0.287) in the probability of females or males being in the high acute care utilization category. As noted in Section 3.7 Analytic Methods, any variable for which the univariate test has a p value of < 0.25 will be considered a candidate for the multivariate model. The 0.25 level has been suggested as an appropriate level for selection of candidate variables as the use of the more traditional level of 0.05 often fails to identify important variables. In addition, any variable of known or hypothesized significance was assessed in the full model regardless of the significance results in the univariate analysis. Thus, the gender of the individual was assessed in the multivariate model, even though there were no significant findings in the initial analysis.

There was a clear relationship between the age of the individual and the probability of being in the high acute care cost category. As expected, those less likely to incur high acute care costs were younger than the reference group of 50-59 years (i.e., 46.0% less likely for 30-39 years; 42.9% less likely for 40-49 years). On the other hand, older individuals tended to incur high acute care costs. Those aged 60-69 were 54% more likely and those aged 70-79 were 290% more likely to be in the high resource use category compared to the reference group. The independent variable of age accounted for 6.4% of the variance in the dependent variable of low or high average annual acute care costs.

Individuals in the lowest two socio-economic status (SES) quintiles were more likely (28.9% and 14.3%, respectively) to be in the high acute care utilization group than those in the middle quintile. The independent variable of SES accounted for 0.2% of the variance in the dependent variable of low or high acute care utilization.

Table 4-40 Univariate Logistic Regression Models for
High vs. Low Utilization of Average Annual Acute Care Costs

	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper	-2 log likelihood	Model X^2	df	*p* -value	Nagelkerke R Square	Selection
By Level of Adherence													
Low	-0.221	0.045	31.4	< 0.001	0.778	0.712	0.849	20,195.8	35.8	2	<0.001	0.003	Yes
Medium	*******												
High	-0.009	0.041	0.0	0.832	0.991	0.914	1.075						
By Sex													
Female	-0.038	0.035	1.1	0.288	0.963	0.899	1.032	20,175.3	1.1	1	0.287	0.000	No
Male	*******												
By Age *(in Year 3)*													
30-39	-0.403	0.109	13.7	< 0.001	0.669	0.540	0.827	19,401.8	829.7	4	<0.001	0.064	Yes
40-49	-0.414	0.075	30.6	< 0.001	0.661	0.571	0.765						
50-59	*******												
60-69	0.432	0.051	71.9	< 0.001	1.540	1.394	1.702						
70-79	1.052	0.050	442.3	< 0.001	2.865	2.597	3.160						
By Socio-Economic Status (in Year 3)													
Quintile 1 (Low)	0.254	0.054	22.3	< 0.001	1.289	1.160	1.432	19,747.5	25.0	4	<0.001	0.002	Yes
Quintile 2	0.134	0.054	6.3	0.012	1.143	1.029	1.270						
Quintile 3	*******												
Quintile 4	0.078	0.055	2.0	0.153	1.081	0.971	1.204						
Quintile 5 (High)	0.052	0.062	0.7	0.400	1.054	0.933	1.190						
By Morbidity													
Very Low	-0.998	0.363	7.6	0.006	0.368	0.181	0.751	17,512.0	2,611.2	4	<0.001	0.193	Yes
Low	-0.451	0.125	13.1	< 0.001	0.637	0.499	0.813						
Medium	*******												
High	1.175	0.069	293.0	< 0.001	3.240	2.832	3.706						
Very High	2.359	0.067	1,228.6	< 0.001	10.580	9.273	12.072						
By Disease-Specific Severity Index													
No Complications	-1.262	0.050	628.0	< 0.001	0.283	0.257	0.312	19,093.7	1,137.8	4	<0.001	0.087	Yes
1 or More Minor Comp.	-0.540	0.042	167.7	< 0.001	0.583	0.537	0.632						
1 or More Intermediate Comp.	*******												
1 Major Comp.	0.712	0.113	39.7	< 0.001	2.039	1.634	2.544						
2 or More Major Comp.	1.739	0.131	175.3	< 0.001	5.691	4.399	7.362						
By Patient Residence (in Year 3)													
LHA 202 - S. Surrey / WR	0.291	0.083	12.3	< 0.001	1.338	1.137	1.575	20,134.3	97.2	12	<0.001	0.008	Yes
LHA 201 - Surrey	*******												
LHA 076 - Agassiz-Harrison	0.346	0.216	2.6	0.109	1.143	0.926	2.157						
LHA 075 - Mission	0.212	0.110	3.7	0.054	1.236	0.997	1.533						
LHA 043 - Coquitlam	0.057	0.064	0.8	0.371	1.059	0.934	1.200						
LHA 042 - Maple Ridge	0.276	0.083	11.1	0.001	1.318	1.121	1.551						
LHA 041 - Burnaby	-0.097	0.060	2.6	0.108	0.908	0.807	1.021						
LHA 040 - New Westminster	0.359	0.087	17.2	< 0.001	1.432	1.208	1.696						
LHA 037 - Delta	0.068	0.078	0.8	0.379	1.071	0.920	1.247						
LHA 035 - Langley	0.315	0.071	19.8	< 0.001	1.370	1.192	1.573						
LHA 034 - Abbotsford	0.309	0.067	21.3	< 0.001	1.362	1.195	1.553						
LHA 033 - Chilliwack	0.351	0.081	18.6	< 0.001	1.420	1.211	1.665						
LHA 032 - Hope	0.783	0.189	17.2	< 0.001	2.189	1.511	3.171						

*Notes: ******* Reference Category*

Patients who were in the very low or low morbidity group were considerably less likely (63.2% and 36.3%, respectively) to be in the high acute care cost group than are those in the medium morbidity group. On the other hand, adults in the high or very high morbidity groups were much more likely to incur high acute care costs (3.2 times and 10.6 times, respectively).

The independent variable of morbidity accounted for 19.3% of the variance in the dependent variable of low or high average annual acute care costs.

Those with no complications or just one or more minor complications were considerably less likely (71.7% and 41.7%, respectively) to be in the high acute care cost category than those who had one or more intermediate complications (i.e., the reference group). The adults with one major complication or two or more major complications differed dramatically from the reference group. They were 200% and 570%, respectively, more likely to be in the high acute care cost category. The independent variable of disease-specific severity index accounted for 8.7% of the variance in the dependent variable of low or high resource use.

Acute care utilization varied considerably between LHAs. In the absence of adjusting for covariates, adults living in the LHAs of South Surrey / White Rock (33.8%), Maple Ridge (31.8%), New Westminster (43.2%), Langley (37.0%), Abbotsford (36.2%), Chilliwack (42.0$) and Hope (118.9%) were all more likely to be in the high acute care cost category than individuals who lived in the reference group of Surrey. The independent variable of patient residence accounted for 0.8% of the variance in the dependent variable of low or high resource use.

4.10 Multivariate Logistic Regression Model for Average Annual Total Acute Care Costs

4.10.1 Development of a Reduced Main Effects Model for Acute Care Costs

As noted in table 4-40, the six independent variables (i.e., adherence, age, SES, morbidity, disease-specific severity and patient residence) assessed in the univariate analysis were all selected for inclusion in the multivariate model based on a p-value < 0.001. Gender was included as of the seventh variable; it was of known or hypothesized significance. These seven independent variables were entered into the Binary Logistic Regression function of SPSS based

on the explanatory power of the variable. Thus the variable morbidity was entered first, followed by disease-specific severity index, age, patient residence, adherence, socio-economic status and gender. Once all of the variables were in the model (the 'full model'), each variable was sequentially removed in reverse order to assess the impact of the exclusion of each variable from the full model. The results are provided in table 4-41.

Table 4-41 Development and Testing of a Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Acute Care Costs

	Intermediate Models						**Full Model**	Assessing the Impact of Removing Individual Variables						
By Level of Adherence					***<0.001***	***<0.001***	***<0.001***	***0.003***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***
Low					1.173	1.164	1.166	0.941	1.114	1.131	1.177		1.173	1.164
Medium	*******													
High					0.774	0.768	0.775	0.858	0.803	0.794	0.765		0.779	0.768
By Sex							***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	
Female							0.723	0.837	0.732	0.750	0.725	0.721	0.737	
Male	*******													
By Age *(in Year 3)*			***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***
30-39			0.581	0.581	0.558	0.561	0.568	0.688	0.599		0.566	0.590	0.566	0.561
40-49			0.668	0.670	0.659	0.654	0.655	0.695	0.644		0.653	0.665	0.662	0.654
50-59	*******													
60-69			1.427	1.425	1.443	1.438	1.435	1.418	1.460		1.437	1.417	1.440	1.438
70-79			2.455	2.421	2.422	2.409	2.462	2.473	2.524		2.510	2.457	2.476	2.409
By Socio-Economic Status (in Year 3)						***0.107***	***0.065***	***0.001***	***0.074***	***0.011***	***0.274***	***0.047***		***0.107***
Quintile 1 (Low)						1.138	1.155	1.250	1.156	1.222	1.113	1.162		1.138
Quintile 2						1.169	1.169	1.197	1.159	1.164	1.130	1.168		1.169
Quintile 3	*******													
Quintile 4						1.104	1.086	1.085	1.088	1.081	1.083	1.079		1.104
Quintile 5 (High)						1.074	1.039	1.024	1.038	1.054	1.061	1.025		1.074
By Morbidity	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Very Low	0.368	0.427	0.421	0.415	0.396	0.409	0.407		0.372	0.415	0.413	0.427	0.394	0.409
Low	0.637	0.688	0.683	0.681	0.665	0.642	0.630		0.601	0.638	0.632	0.645	0.653	0.642
Medium	*******													
High	3.240	2.894	2.825	2.818	2.901	2.912	2.983		3.217	3.049	3.001	2.899	2.964	2.912
Very High	10.58	8.477	8.533	8.602	8.992	8.991	9.354		10.927	9.244	9.317	8.957	9.330	8.991
By Disease-Specific Severity Index		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
No Complications		0.515	0.679	0.678	0.645	0.640	0.636	0.359		0.487	0.634	0.668	0.641	0.640
1 or More Minor Comp.		0.832	0.970	0.975	0.943	0.939	0.944	0.665		0.817	0.936	0.977	0.948	0.939
1 or More Intermediate Comp.	*******													
1 Major Comp.		1.746	2.045	2.061	2.059	1.994	2.028	2.354		1.718	2.012	2.033	2.092	1.994
2 or More Major Comp.		4.514	6.250	6.186	6.240	6.035	5.980	7.292		4.322	6.067	5.929	6.184	6.035
By Patient Residence (in Year 3)				***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***
LHA 202 - S. Surrey / WR				1.152	1.188	1.215	1.225	1.209	1.189	1.551		1.197	1.178	1.215
LHA 201 - Surrey	*******													
LHA 076 - Agassiz-Harrison				1.408	1.433	0.454	0.437	0.557	0.410	0.527		0.422	1.360	0.454
LHA 075 - Mission				1.303	1.272	1.268	1.276	1.258	1.241	1.372		1.307	1.283	1.268
LHA 043 - Coquitlam				1.173	1.177	1.187	1.196	1.053	1.206	1.261		1.198	1.175	1.187
LHA 042 - Maple Ridge				1.390	1.368	1.431	1.446	1.385	1.458	1.553		1.466	1.376	1.431
LHA 041 - Burnaby				0.890	0.917	0.919	0.925	0.850	0.911	1.024		0.899	0.920	0.919
LHA 040 - New Westminster				1.377	1.394	1.387	1.412	1.256	1.437	1.520		1.397	1.410	1.387
LHA 037 - Delta				1.136	1.145	1.170	1.181	1.116	1.176	1.221		1.178	1.138	1.170
LHA 035 - Langley				1.266	1.306	1.305	1.309	1.206	1.334	1.447		1.274	1.301	1.305
LHA 034 - Abbotsford				1.435	1.410	1.431	1.424	1.290	1.389	1.606		1.453	1.394	1.431
LHA 033 - Chilliwack				1.265	1.273	1.256	1.255	1.157	1.282	1.426		1.249	1.267	1.256
LHA 032 - Hope				1.767	1.750	1.929	1.978	2.301	1.920	2.344		1.997	1.793	1.929
-2 log likelihood	17,512	17,146	16,621	16,552	16,494	16,107	16,003	17,965	16,304	16,509	16,070	16,057	16,320	16,107
Likelihood Ratio Test X_2	2,611	2,977	3,502	3,571	3,629	3,557	3,615	1,761	3,314	3,181	3,548	3,561	3,676	3,557
Degrees of Freedom	4	8	12	24	26	30	31	27	27	27	19	29	27	30
p - value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nagelkerke R Square	0.193	0.218	0.253	0.257	0.261	0.262	0.266	0.135	0.246	0.232	0.262	0.263	0.265	0.262
Hosmer & Lemeshow GOF	1.000	0.082	0.007	0.633	0.656	0.627	0.526	0.024	0.458	0.108	0.029	0.142	0.335	0.627
Change in -2 Log Likelihood if Variable Removed								1,856	302	507	67	54	9	65
p - value of Change								<0.001	<0.001	<0.001	<0.001	<0.001	0.064	<0.001

*Notes: ******* Reference Category*
Significant Odds Ratios (OR) are highlighted in yellow.
The p-value for each (grouped) variable is provided in ***bolded italics*** *above the first OR value for that group.*

Table 4-42 presents the detailed results of the main effects model. Six of the seven variables were significant predictors of the probability of being in the category of high acute care utilization, defined by average annual acute care costs. Only SES was not a significant predictor.

Table 4-42 Main Effects Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Acute Care Costs

	p-value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Level of Adherence	***<0.001***							
Low		0.159	0.051	9.650	0.002	1.173	1.061	1.297
Medium		*******						
High		-0.249	0.046	29.009	< 0.001	0.779	0.712	0.853
By Sex	***<0.001***							
Female		-0.305	0.040	59.025	< 0.001	0.737	0.682	0.797
Male		*******						
By Age *(in Year 3)*	***<0.001***							
30-39		-0.569	0.126	20.519	< 0.001	0.566	0.443	0.724
40-49		-0.413	0.080	26.510	< 0.001	0.662	0.565	0.774
50-59		*******						
60-69		0.364	0.056	43.103	< 0.001	1.440	1.291	1.605
70-79		0.907	0.055	267.039	< 0.001	2.476	2.221	2.761
By Morbidity	***<0.001***							
Very Low		-0.931	0.365	6.510	0.011	0.394	0.193	0.806
Low		-0.426	0.126	11.325	0.001	0.653	0.510	0.837
Medium		*******						
High		1.087	0.071	237.382	< 0.001	2.964	2.581	3.403
Very High		2.233	0.071	999.709	< 0.001	9.330	8.124	10.715
By Disease-Specific Severity Index	***<0.001***							
No Complications		-0.445	0.057	60.300	< 0.001	0.641	0.573	0.717
1 or More Minor Comp.		-0.054	0.047	1.337	0.248	0.948	0.865	1.038
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.738	0.124	35.597	< 0.001	2.092	1.642	2.667
2 or More Major Comp.		1.822	0.143	161.233	< 0.001	6.184	4.668	8.192
By Patient Residence (in Year 3)	***<0.001***							
LHA 202 - S. Surrey / WR		0.164	0.093	3.081	0.079	1.178	0.981	1.414
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		0.308	0.244	1.593	0.207	1.360	0.844	2.193
LHA 075 - Mission		0.250	0.122	4.190	0.041	1.283	1.011	1.630
LHA 043 - Coquitlam		0.162	0.071	5.137	0.023	1.175	1.022	1.352
LHA 042 - Maple Ridge		0.320	0.093	11.901	0.001	1.376	1.148	1.651
LHA 041 - Burnaby		-0.084	0.067	1.581	0.209	0.920	0.807	1.048
LHA 040 - New Westminster		0.344	0.097	12.538	0.000	1.410	1.166	1.706
LHA 037 - Delta		0.129	0.086	2.236	0.135	1.138	0.961	1.347
LHA 035 - Langley		0.263	0.079	10.945	0.001	1.301	1.113	1.520
LHA 034 - Abbotsford		0.332	0.075	19.720	< 0.001	1.394	1.204	1.615
LHA 033 - Chilliwack		0.237	0.091	6.773	0.009	1.267	1.060	1.515
LHA 032 - Hope		0.584	0.214	7.415	0.006	1.793	1.178	2.730

FITTED MODEL		
	-2 log likelihood	16,391.9
	Likelihood Ratio Test X^2	3,676.3
	Degrees of Freedom	27
	p - value	<0.001
	Nagelkerke R Square	0.265
	Hosmer & Lemeshow GOF	0.335

*Notes: ******* Reference Category*

4.10.2 Development of a Final Fitted Model for Acute Care Costs

After the development of the main effects model, all possible two-way interactions were tested individually based on Wald statistics and their *p*-values. All but one (i.e., adherence by gender) potential two-factor term was found to be significant. To assess these potential interactions in the model, the main effects were entered as a block and the potential two-way interactions were included as a second block using the forward stepwise (likelihood ratio) approach. This analysis identified three two-way interactions that remained significant after adjusting for the other variables in the model; general morbidity by DSS Index (p=0.023), general morbidity by adherence (p=0.002) and age group by DSS Index (p=0.001).

Potential three-way interactions were selected (based on the significant two-way interaction variables). The three-way interactions were then tested individually based on Wald statistics and their *p*-values and found to be significant. The significant three-way interactions were then included with the two-way interactions in the second block. After adjusting for the main effects in the model and potential interactions (i.e., both two-way and three-way), none of the interactions remained significant. They were subsequently excluded from the final fitted model. The final fitted model was therefore identical to the main effects model shown in table 4-42.

4.10.3 Interpretation of the Final Fitted Model for Acute Care Costs

After adjusting for the covariates in the model, patients in the low adherence group were 17.3% more likely to be in the high acute care cost category than patients in the medium adherence category. Individuals in the high adherence group, on the other hand, were 22.1% less likely to be in the high acute care cost category than the reference group.

This relationship between adherence and the probability of high acute care utilization was directly opposite that of the relationship between adherence and high physician utilization. Specifically, after adjusting for the covariates in the models, individuals in the low adherence group were 16.6% less likely to be in the high physician resource category but 17.3% more likely to be in the high acute care resource category. Individuals in the high adherence group, on the other hand, were 37.2% more likely to be in the high physician resource category but 22.1% less likely to be in the high acute care resource category.

The preliminary univariate analysis indicated no significant difference between males and females in the probability of being in the high resource use category. After adjusting for the covariates in the model, however, it became obvious that there was a difference between the sexes. Females were 26.3% less likely (OR=0.737) to be in the high acute care cost group than males.

The clear relationship between the age of the individual and the probability of being in the high resource use category remained even after adjusting for the covariates in the model. Younger adults were less likely to be in the high resource use category compared to the reference group of 50-59 year olds. Older individuals were more likely to be in the high resource use category. Those aged 60-69 were 44.0% more likely and those aged 70-79 were 250 % (OR=2.476) more likely to be in the high resource use category compared to the reference group.

The multivariate analysis confirmed the strong relationship between poor health and acute care utilization. Adults with diagnosed type 2 diabetes who were in the very low and low morbidity group remained considerably less likely (60.6% and 34.7%, respectively) to be in the high resource use group than those in the medium morbidity group. Adults in the high or very high morbidity groups were considerably more likely to be in the high resource use category (OR

of 2.964 and 9.330, respectively). Similarly, the multivariate analysis confirmed that patients with no complications were 35.9% less likely to be in the high resource use group than are those who had one or more intermediate complications (i.e., the reference group). On the other hand, adults with one or multiple major complications were 2.1 and 6.2 times more likely to be in the high resource use category.

The LHA of Surrey, which was the reference group for place of residence, compared favourably with the other LHAs. Patients living in the LHAs of Mission (28.3%), Coquitlam (17.5%), Maple Ridge (37.6%), New Westminster (41.0%), Langley (30.1%), Abbotsford (39.4%), Chilliwack (26.7%) and Hope (79.3%) were all more likely to be in the high resource use group than individuals who live in the LHA of Surrey.

The overall final model explained a significant proportion of the variation in the probability of being in the high acute care resource use group with a Chi-square test statistic of 3,676.3 (27 *df*) which corresponds to a *p*-value of less than 0.001. The Nagelkerke R Square was 0.265, indicating that 26.5% of the total variance was explained by the model.

The goodness of fit of the multivariate model was assessed using the Hosmer & Lemeshow GOF test. The Hosmer & Lemeshow statistic was 9.1 with 8 *df* which was not statistically significant ($p = 0.335$) indicating that the model was an adequate fit for the observed data.

In summary, after adjusting for six factors (i.e., the individual's level of adherence, gender, age, general morbidity, disease-specific morbidity and geographic location of residence) a number of patient characteristics predicted whether an individual is more or less likely to be in the high or low average annual acute care cost category. The patients who were less likely to be in the high acute care costs category were:

- females
- younger adults
- those with a very low or low level of co-morbidity
- those with no diabetes disease-specific complications

The patients who were more likely to be in the high acute care costs category were:

- males
- older individuals
- those in the lowest SES category
- those with a high or very high level of co-morbidity
- those with one or more major diabetes disease-specific complications
- those living in the LHAs of Mission, Coquitlam, Maple Ridge, New Westminster, Langley, Abbotsford, Chilliwack and Hope

4.11 Univariate Logistic Regression Models for Average Annual Total Costs

In this section, physician and acute care costs are combined into total costs.

Table 4-43 provides the results of the univariate logistic regression models comparing high versus low utilization of average annual total costs during the five year study period (April 1, 1996 to March 31, 2001). Which patient characteristics had a significant effect on whether or not individuals are in the high versus low total cost category?

Patients in the low adherence category were 25.0% (OR of 0.750) less likely to be in the high resource use group compared to adults in the medium adherence category (i.e., the reference group). On its own, however, the independent variable of adherence accounted for just 0.04% of the variance (Nagelkerke R Square of .004) in the dependent variable of low or high average annual resource use.

Table 4-43 Univariate Logistic Regression Models for
High vs. Low Utilization of Average Annual Total Costs

	BETA	S.E.	Wald	*p*-value	OR	95% C.I. for Exp(B) Lower	95% C.I. for Exp(B) Upper	-2 log likelihood	Model X^2	df	*p*-value	Nagelkerke R Square	Selection
By Level of Adherence													
Low	-0.287	0.045	40.2	< 0.001	0.750	0.687	0.820	20,169.9	53.3	2	< 0.001	0.004	Yes
Medium	*******												
High	0.040	0.041	0.9	0.335	1.040	0.960	1.128						
By Sex													
Female	-0.030	0.035	0.7	0.393	0.970	0.905	1.040	20,170.2	0.7	1	0.393	0.000	No
Male	*******												
By Age *(in Year 3)*													
30-39	-0.391	0.107	13.4	< 0.001	0.677	0.549	0.834	19,458.3	764.9	4	< 0.001	0.059	Yes
40-49	-0.394	0.073	28.9	< 0.001	0.675	0.584	0.779						
50-59	*******												
60-69	0.358	0.051	49.7	< 0.001	1.430	1.295	1.580						
70-79	1.004	0.040	409.4	< 0.001	2.730	2.477	3.010						
By Socio-Economic Status (in Year 3)													
Quintile 1 (Low)	0.315	0.053	34.7	< 0.001	1.370	1.234	1.521	19,721.6	39.7	4	< 0.001	0.003	Yes
Quintile 2	0.134	0.054	6.2	0.013	1.144	1.029	1.271						
Quintile 3	*******												
Quintile 4	0.076	0.055	1.9	0.169	1.079	0.968	1.201						
Quintile 5 (High)	0.052	0.062	0.7	0.401	1.054	0.933	1.190						
By Morbidity													
Very Low	-1.160	0.417	7.7	0.005	0.314	0.138	0.710	17,121.5	2,974.0	4	< 0.001	0.218	Yes
Low	-0.524	0.136	14.9	< 0.001	0.592	0.454	0.773						
Medium	*******												
High	1.265	0.072	307.1	< 0.001	3.544	3.076	4.083						
Very High	2.555	0.071	1,307.4	< 0.001	12.874	11.209	14.786						
By Disease-Specific Severity Index													
No Complications	-1.326	0.051	676.1	< 0.001	0.266	0.240	0.294	19,051.8	1,171.4	4	< 0.001	0.089	Yes
1 or More Minor Comp.	-0.545	0.042	172.2	< 0.001	0.580	0.534	0.629						
1 or More Intermediate Comp.	*******												
1 Major Comp.	0.685	0.113	36.7	< 0.001	1.983	1.589	2.475						
2 or More Major Comp.	1.626	0.129	158.5	< 0.001	5.084	3.947	6.549						
By Patient Residence (in Year 3)													
LHA 202 - S. Surrey / WR	0.225	0.083	7.3	0.007	1.252	1.064	1.475	20,147.3	75.9	12	< 0.001	0.006	Yes
LHA 201 - Surrey	*******												
LHA 076 - Agassiz-Harrison	0.209	0.221	0.9	0.344	1.233	0.799	1.900						
LHA 075 - Mission	0.168	0.110	2.3	0.126	1.183	0.954	1.466						
LHA 043 - Coquitlam	-0.025	0.064	0.2	0.696	0.975	0.860	1.106						
LHA 042 - Maple Ridge	0.254	0.082	9.6	0.002	1.289	1.097	1.514						
LHA 041 - Burnaby	-0.125	0.060	4.4	0.036	0.882	0.785	0.992						
LHA 040 - New Westminster	0.333	0.086	15.0	< 0.001	1.395	1.178	1.651						
LHA 037 - Delta	0.047	0.077	0.4	0.539	1.048	0.901	1.219						
LHA 035 - Langley	0.219	0.071	9.5	0.002	1.245	1.083	1.432						
LHA 034 - Abbotsford	0.237	0.067	12.5	< 0.001	1.267	1.111	1.445						
LHA 033 - Chilliwack	0.264	0.082	10.5	0.001	1.303	1.110	1.529						
LHA 032 - Hope	0.634	0.193	10.8	0.001	1.885	1.292	2.750						

*Notes: ******* Reference Category*

In the absence of adjustment for other covariates in the model, there were no significant differences (p=0.393) in the probability of females or males being in the high resource use category. As noted in Section 3.6 Analytic Methods, any variable of known or hypothesized significance was assessed in the full model regardless of the significance results in the univariate

analysis. Therefore, the gender of the individual was assessed in the multivariate model, even thought it was not statistically significant in the preliminary analysis.

There is a clear relationship between the age of the individual and the probability of being in the high resource use category. Adults aged 30-49 were approximately 22% less likely to be in the high resource use group compared to adults aged 50-59 (i.e., the reference group). On the other hand, older individuals were more likely to be in the high resource use category. Those aged 60-69 were 43% more likely and those aged 70-79 were 173% more likely to be in the high resource use category compared to the reference group. The independent variable of age accounted for 5.9% of the variance in the dependent variable of low or high resource use.

Individuals in the two lowest socio-economic status (SES) quintiles were more likely to be in the high resource use group than those in quintile 3, the reference group. Those in quintile 1 were 37.0% more likely to be in the high resource use group and those in quintile 2 were 14.4% more likely to be in the high resource use group. The independent variable of SES accounted for 0.3% of the variance in the dependent variable of low or high resource use.

Patients in the very low and low morbidity groups were considerably less likely (68.6% and 40.8%, respectively) to be in the high resource use category than those in the medium morbidity group. As expected, patients in the high or very high morbidity groups were more likely to be in the high resource use category (3.5 times and 12.9 times, respectively). The independent variable of morbidity accounted for 21.8% of the variance in the dependent variable of low or high resource use.

Patients with one major complication or two or more major complications were 2.0 and 5.1 times, respectively, more likely to be in the high resource use category. The analysis confirmed that patients with no complications or just one or more minor complications were

considerably less likely (73.4% and 42.0%, respectively) to be in the high resource use group. The independent variable of disease-specific severity index accounted for 8.9% of the variance in the dependent variable of low or high resource use.

In the analysis for place of residence, the results for total health care utilization mirrored the findings for acute care utilization. That is, individuals living in the majority of LHA's were more likely to be in the high resource use category than the reference group living in Surrey. Specifically, individuals living in the LHAs of Hope (88.5%), New Westminster (39.5%), Chilliwack (30.3%), Maple Ridge (28.9%), Abbotsford (26.7%), South Surrey/White Rock (25.2%) and Langley (24.5%) were all more likely to be in the high resource use group. Only individuals living in the LHA of Burnaby (OR=0.882) were less likely to be in the high resource use group than individuals who lived in the LHA of Surrey. The independent variable of patient residence accounted for 0.6% of the variance in the dependent variable of low or high resource use.

As noted in table 4-41, the six independent variables (i.e., adherence, age, SES, morbidity, disease-specific severity and patient residence) assessed in the univariate analysis were all selected for inclusion in the multivariate model based on a *p*-value of less 0.001. A seventh variable, the independent variable of gender, was included for assessment due to the probable significance of this variable on resource use.

4.12 Multivariate Logistic Regression Model for Average Annual Total Costs

4.12.1 Development of a Reduced Main Effects Model for Total Costs

The seven independent variables were entered into the Binary Logistic Regression function of SPSS based on the explanatory power of the variable. Thus the variable of morbidity was entered first, followed by disease-specific severity index, age, patient residence, adherence,

socio-economic status and gender. Once all of the variables were in the model, each variable was sequentially removed in reverse order to assess the impact of the exclusion of each variable from the full model. The results are provided in table 4-44.

Table 4-44 Development and Testing of a Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Costs

	Intermediate Models						**Full Model**	Assessing the Impact of Removing Individual Variables						
By Level of Adherence					***<0.001***	***<0.001***	***<0.001***	***0.033***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***
Low					1.148	1.137	1.140	0.902	1.087	1.110	1.150		1.151	1.137
Medium	*******													
High					0.816	0.811	0.819	0.911	0.846	0.834	0.807		0.823	0.811
By Sex							***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	
Female							0.709	0.837	0.718	0.735	0.711	0.707	0.724	
Male	*******													
By Age *(in Year 3)*			***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***
30-39			0.563	0.561	0.542	0.543	0.550	0.715	0.570		0.551	0.567	0.550	0.543
40-49			0.681	0.682	0.673	0.667	0.668	0.716	0.653		0.668	0.676	0.675	0.667
50-59	*******													
60-69			1.305	1.305	1.317	1.308	1.304	1.293	1.334		1.303	1.291	1.315	1.308
70-79			2.315	2.293	2.292	2.265	2.316	2.314	2.389		2.349	2.314	2.345	2.265
By Socio-Economic Status (in Year 3)						***0.034***	***0.013***	***<0.001***	***0.013***	***0.001***	***0.062***	***0.008***		***0.034***
Quintile 1 (Low)						1.208	1.228	1.335	1.228	1.293	1.188	1.234		1.208
Quintile 2						1.158	1.158	1.191	1.148	1.155	1.123	1.157		1.158
Quintile 3														
Quintile 4						1.108	1.089	1.089	1.091	1.085	1.079	1.083		1.108
Quintile 5 (High)						1.084	1.048	1.031	1.046	1.062	1.065	1.036		1.084
By Morbidity	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Very Low	0.314	0.364	0.360	0.356	0.342	0.356	0.354		0.321	0.360	0.358	0.368	0.340	0.356
Low	0.592	0.641	0.637	0.636	0.623	0.597	0.584		0.555	0.591	0.585	0.595	0.610	0.597
Medium	*******													
High	3.544	3.167	3.093	3.083	3.157	3.185	3.270		3.528	3.341	3.290	3.195	3.234	3.185
Very High	12.87	10.35	10.43	10.49	10.88	10.91	11.40		13.295	11.263	11.365	11.012	11.349	10.91
By Disease-Specific Severity Index		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
No Complications		0.501	0.649	0.648	0.622	0.617	0.613	0.335		0.477	0.611	0.638	0.619	0.617
1 or More Minor Comp.		0.846	0.980	0.983	0.956	0.950	0.955	0.659		0.831	0.949	0.982	0.961	0.950
1 or More Intermediate Comp.	*******													
1 Major Comp.		1.685	1.955	1.969	1.967	1.897	1.930	2.247		1.653	1.917	1.935	2.000	1.897
2 or More Major Comp.		3.963	5.333	5.276	5.304	5.119	5.071	6.248		3.775	5.145	5.046	5.257	5.119
By Patient Residence (in Year 3)				***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***		***<0.001***	***<0.001***	***<0.001***
LHA 202 - S. Surrey / WR				1.089	1.116	1.154	1.163	1.148	1.130	1.462		1.142	1.106	1.154
LHA 201 - Surrey	*******													
LHA 076 - Agassiz-Harrison				1.220	1.238	0.266	0.256	0.343	0.242	0.302		0.248	1.236	0.266
LHA 075 - Mission				1.263	1.237	1.213	1.218	1.194	1.184	1.309		1.243	1.247	1.213
LHA 043 - Coquitlam				1.093	1.096	1.116	1.125	0.977	1.137	1.186		1.127	1.094	1.116
LHA 042 - Maple Ridge				1.368	1.351	1.416	1.431	1.372	1.442	1.533		1.448	1.359	1.416
LHA 041 - Burnaby				0.873	0.895	0.900	0.907	0.828	0.894	0.999		0.887	0.897	0.900
LHA 040 - New Westminster				1.362	1.375	1.371	1.397	1.222	1.425	1.503		1.386	1.393	1.371
LHA 037 - Delta				1.119	1.126	1.165	1.176	1.108	1.173	1.215		1.174	1.118	1.165
LHA 035 - Langley				1.144	1.173	1.182	1.184	1.092	1.210	1.311		1.159	1.167	1.182
LHA 034 - Abbotsford				1.345	1.325	1.351	1.344	1.210	1.312	1.508		1.367	1.310	1.351
LHA 033 - Chilliwack				1.165	1.171	1.140	1.138	1.048	1.165	1.287		1.134	1.164	1.140
LHA 032 - Hope				1.478	1.465	1.642	1.680	2.000	1.639	1.991		1.694	1.497	1.642
-2 log likelihood	17,122	16,775	16,308	16,255	16,217	15,825	15,713	17,995	15,990	16,164	15,769	15,746	16,109	15,825
Likelihood Ratio Test X_2	2,974	3,321	3,788	3,841	3,879	3,809	3,874	1,720	3,597	3,424	3,818	3,840	3,934	3,809
Degrees of Freedom	4	8	12	24	26	30	31	27	27	27	19	29	27	30
p - value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nagelkerke R Square	0.218	0.241	0.272	0.275	0.278	0.279	0.284	0.132	0.265	0.253	0.280	0.281	0.282	0.279
Hosmer & Lemeshow GOF	1.000	0.119	0.071	0.420	0.391	0.867	0.464	0.001	0.186	0.350	0.253	0.075	0.208	0.867
Change in -2 Log Likelihood if Variable Removed								2,147	277	450	56	34	13	72
p - value of Change								<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0013

*Notes: ******* Reference Category*

Significant Odds Ratios (OR) are highlighted in yellow.

The p-value for each (grouped) variable is provided in ***bolded italics*** *above the first OR value for that group.*

Table 4-45 presents the detailed results of the main effects model. All seven of the patient characteristics, including gender, were significant predictors of the probability of being in the high utilization of average annual total cost category.

Table 4-45 Main Effects Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Costs

	p -value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Level of Adherence	***<0.001***							
Low		0.131	0.053	6.1	0.013	1.140	1.027	1.264
Medium		*******						
High		-0.199	0.047	18.1	< 0.001	0.819	0.747	0.898
By Sex	***<0.001***							
Female		-0.344	0.041	71.1	< 0.001	0.709	0.655	0.768
Male		*******						
By Age *(in Year 3)*	***<0.001***							
30-39		-0.598	0.127	22.1	< 0.001	0.550	0.429	0.706
40-49		-0.403	0.080	25.2	< 0.001	0.668	0.571	0.782
50-59		*******						
60-69		0.265	0.056	22.1	< 0.001	1.304	1.167	1.456
70-79		0.840	0.056	221.4	< 0.001	2.316	2.074	2.587
By Socio-Economic Status (in Year 3)	***0.013***							
Quintile 1 (Low)		0.205	0.062	11.0	0.001	1.228	1.088	1.386
Quintile 2		0.147	0.061	5.7	0.017	1.158	1.027	1.306
Quintile 3		*******						
Quintile 4		0.086	0.063	1.9	0.173	1.089	0.963	1.233
Quintile 5 (High)		0.047	0.073	0.4	0.519	1.048	0.909	1.208
By Morbidity	***<0.001***							
Very Low		-1.038	0.419	6.1	0.013	0.354	0.156	0.805
Low		-0.538	0.142	14.3	< 0.001	0.584	0.442	0.771
Medium		*******						
High		1.185	0.075	248.0	< 0.001	3.270	2.822	3.789
Very High		2.434	0.075	1050.4	< 0.001	11.400	9.840	13.207
By Disease-Specific Severity Index	***<0.001***							
No Complications		-0.489	0.059	68.7	< 0.001	0.613	0.546	0.688
1 or More Minor Comp.		-0.046	0.047	0.9	0.332	0.955	0.871	1.048
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.658	0.127	27.0	< 0.001	1.930	1.506	2.474
2 or More Major Comp.		1.624	0.143	129.3	< 0.001	5.071	3.833	6.709
By Patient Residence (in Year 3)	***<0.001***							
LHA 202 - S. Surrey / WR		0.151	0.098	2.4	0.122	1.163	0.960	1.409
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		-1.362	0.765	3.2	0.075	0.256	0.057	1.147
LHA 075 - Mission		0.198	0.125	2.5	0.115	1.218	0.953	1.557
LHA 043 - Coquitlam		0.118	0.074	2.6	0.110	1.125	0.974	1.301
LHA 042 - Maple Ridge		0.359	0.096	14.0	< 0.001	1.431	1.187	1.727
LHA 041 - Burnaby		-0.098	0.067	2.1	0.145	0.907	0.795	1.034
LHA 040 - New Westminster		0.334	0.098	11.7	0.001	1.397	1.153	1.693
LHA 037 - Delta		0.162	0.090	3.2	0.072	1.176	0.986	1.403
LHA 035 - Langley		0.169	0.083	4.2	0.041	1.184	1.007	1.393
LHA 034 - Abbotsford		0.296	0.077	14.8	< 0.001	1.344	1.156	1.562
LHA 033 - Chilliwack		0.129	0.096	1.8	0.178	1.138	0.943	1.374
LHA 032 - Hope		0.519	0.223	5.4	0.020	1.680	1.085	2.601

-2 log likelihood	15,713.4
Likelihood Ratio Test X_2	3,873.9
Degrees of Freedom	31
p - value	<0.001
Nagelkerke R Square	0.284
Hosmer & Lemeshow GOF	0.464

*Notes: ******* Reference Category*

4.12.2 Development of a Final Fitted Model for Total Costs

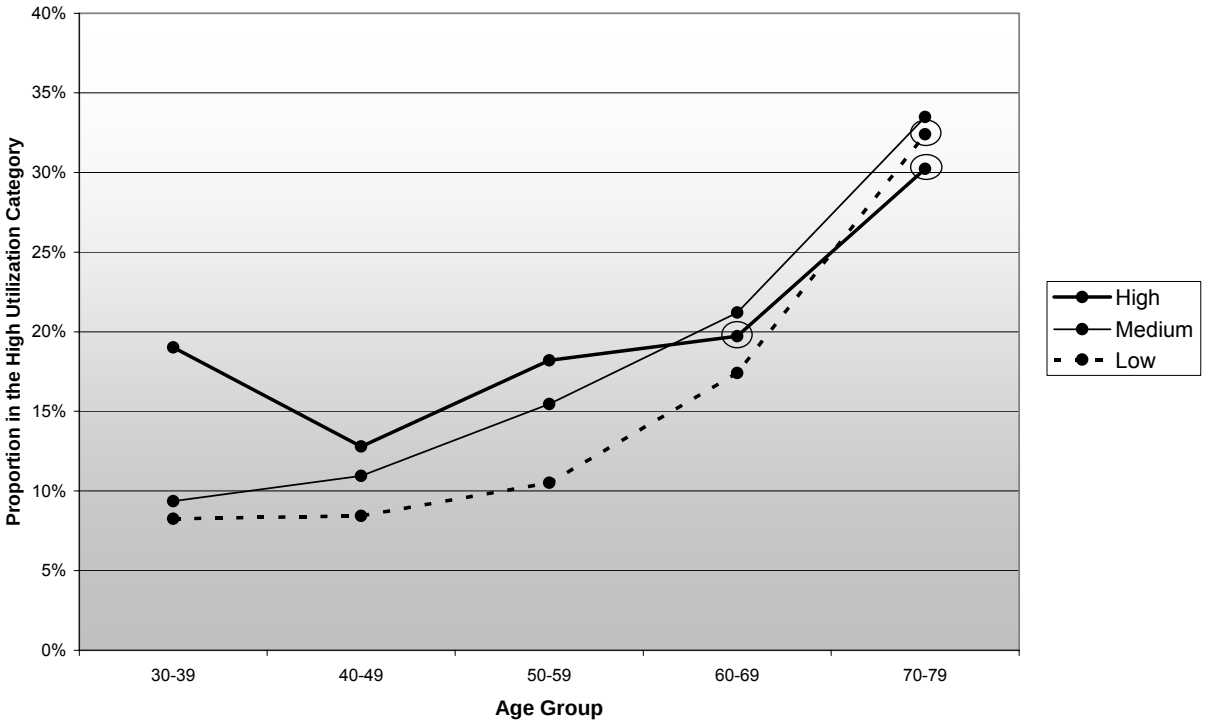
After the development of the main effects model, all possible two-way interactions were tested individually based on Wald statistics and their *p*-values. All but one potential two-factor term (i.e., adherence by gender) was found to be significant. To assess these potential interactions in the model, the main effects were entered as a block and the potential two-way interactions were included as a second block using the Forward Stepwise (Likelihood Ratio) approach. This analysis identified four two-way interactions that remained significant after adjusting for the other variables in the model: morbidity by adherence (p=0.033); age group by DSS Index (p=0.036); age group by adherence (p=0.005); and, socio-economic status by gender (p=0.032).

Potential three-way interactions were selected based on the significant two-way interaction variables. These were then tested individually based on Wald statistics and their *p*-values and found to be significant. The significant three-way interactions were subsequently included with the two-way interactions in the second block. Three of the original four two-way interactions remained significant: age group by adherence (p=0.001); morbidity by adherence (p=0.035); and socio-economic status by gender (p=0.027). These three significant two-way interactions were included with the main effects in the final fitted model.

The relationship between age, adherence, and health care utilization is shown on figure 4-9. The key interactions are circled on figure 4-9 (see also table 4-46). In the younger age groups (ages 30-59), there was a clear relationship between adherence and the probability of being in the higher resource use category. Specifically those in the low adherence category were less likely to be in the high resource use group while those in the high adherence category were more likely to

be in the high resource use group. This relationship was not upheld in older individuals (ages 60-79).

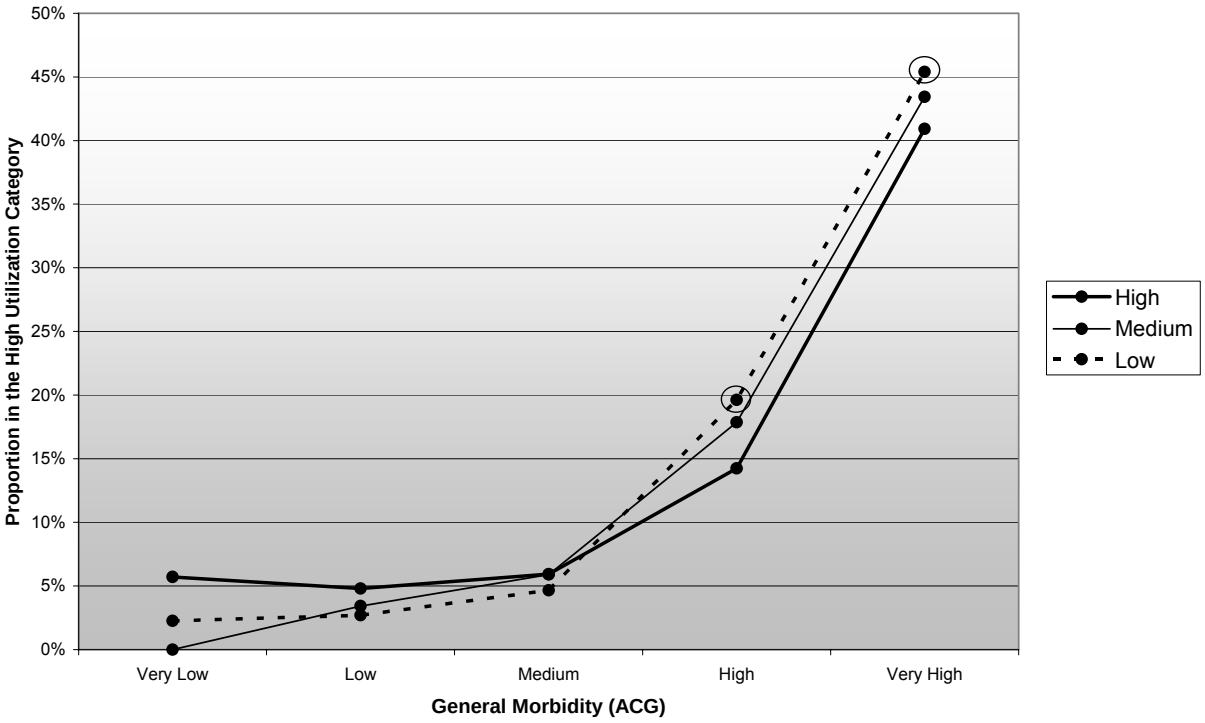
Figure 4-9 Age by Adherence Interaction



The relationship between morbidity, adherence and health care utilization is shown in figure 4-10. There were two significant interactions identified for the low adherence group. These results are circled on figure 4-10 (see also table 4-46). The graph displays that patients in the low adherence category were generally less likely to be in the high resource use group compared to individuals in the high adherence category. This relationship, however, was not sustained in the high or very high morbidity categories. In these two categories, individuals in the low adherence group were more likely to be in the high resource use category compared to individuals in the high adherence group. Thus the data once again highlighted the high cost of

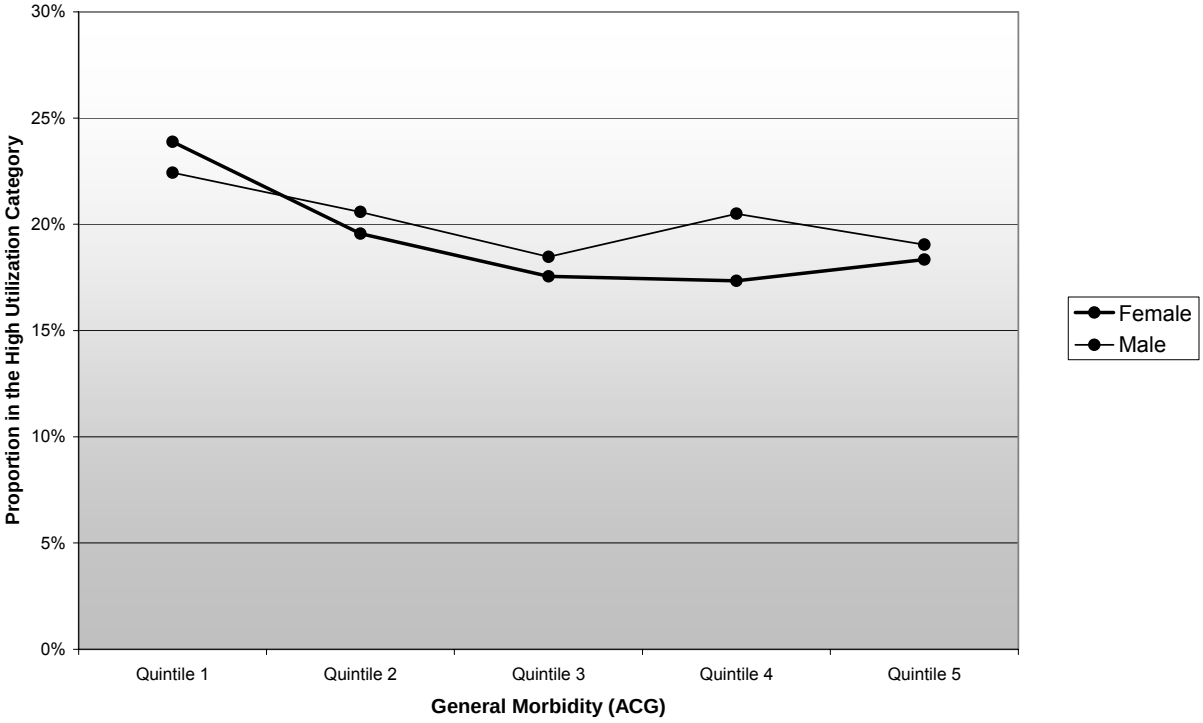
caring for elderly patients with diabetes, particularly those whose diabetes was not well-managed.

Figure 4-10 Morbidity by Adherence Interaction



The interaction between socio-economic status and gender is shown on figure 4-11. While this overall two-way interaction is significant, no individual interaction between a specific SES quintile and gender is significant (see table 4-46). Figure 4-11 does reveal that males were more likely to be in the high resource use category at every SES quintile, with the exception of the lowest SES quintile (quintile 1). In quintile 1, females were more likely to be in the high resource use category.

Figure 4-11 Socio-economic Status by Gender Interaction



The final fitted model, including the main effects and the three significant two-way interactions, is shown on table 4-46.

Table 4-46 Final Multivariate Logistic Regression Model for High vs. Low Utilization of Average Annual Total Costs

	p -value For Group	BETA	S.E.	Wald	*p* -value	OR	95% C.I. for Exp(B) Lower	Upper
By Level of Adherence	***0.049***							
Low		-0.394	0.193	4.2	0.041	0.674	0.462	0.984
Medium		*******						
High		0.116	0.190	0.4	0.542	1.123	0.774	1.628
By Sex	***<0.001***							
Female		-0.375	0.086	19.0	< 0.001	0.687	0.581	0.813
Male		*******						
By Age *(in Year 3)*	***<0.001***							
30-39		-0.668	0.195	11.7	0.001	0.513	0.350	0.752
40-49		-0.402	0.115	12.2	< 0.001	0.669	0.534	0.838
50-59		*******						
60-69		0.318	0.080	15.8	< 0.001	1.375	1.175	1.608
70-79		0.854	0.080	113.4	< 0.001	2.348	2.007	2.747
By Socio-Economic Status (in Year 3)	***0.215***							
Quintile 1 (Low)		0.125	0.087	2.1	0.147	1.134	0.957	1.343
Quintile 2		0.102	0.084	1.5	0.224	1.107	0.940	1.304
Quintile 3		*******						
Quintile 4		0.176	0.083	4.5	0.034	1.192	1.013	1.402
Quintile 5 (High)		0.020	0.094	0.0	0.832	1.020	0.849	1.226
By Morbidity	***<0.001***							
Very Low		-18.306	3,686.4	0.0	0.996	0.000	0.000 .	
Low		-0.596	0.215	7.7	0.006	0.551	0.361	0.840
Medium		*******						
High		1.123	0.106	113.0	< 0.001	3.075	2.500	3.782
Very High		2.330	0.105	496.8	< 0.001	10.277	8.373	12.614
By Disease-Specific Severity Index	***<0.001***							
No Complications		-0.499	0.059	71.4	< 0.001	0.607	0.541	0.681
1 or More Minor Comp.		-0.063	0.048	1.8	0.184	0.939	0.855	1.030
1 or More Intermediate Comp.		*******						
1 Major Comp.		0.657	0.127	26.7	< 0.001	1.929	1.504	2.474
2 or More Major Comp.		1.616	0.144	126.7	< 0.001	5.031	3.797	6.665
By Patient Residence (in Year 3)	***<0.001***							
LHA 202 - S. Surrey / WR		0.158	0.098	2.6	0.107	1.171	0.966	1.419
LHA 201 - Surrey		*******						
LHA 076 - Agassiz-Harrison		-1.356	0.765	3.1	0.076	0.258	0.058	1.154
LHA 075 - Mission		0.188	0.126	2.2	0.134	1.207	0.943	1.545
LHA 043 - Coquitlam		0.110	0.074	2.2	0.139	1.116	0.965	1.290
LHA 042 - Maple Ridge		0.353	0.096	13.5	< 0.001	1.423	1.179	1.718
LHA 041 - Burnaby		-0.094	0.067	1.9	0.164	0.911	0.798	1.039
LHA 040 - New Westminster		0.337	0.098	11.8	0.001	1.400	1.156	1.697
LHA 037 - Delta		0.162	0.090	3.2	0.072	1.176	0.986	1.404
LHA 035 - Langley		0.170	0.083	4.2	0.040	1.185	1.008	1.394
LHA 034 - Abbotsford		0.293	0.077	14.4	< 0.001	1.340	1.152	1.559
LHA 033 - Chilliwack		0.123	0.096	1.6	0.203	1.130	0.936	1.365
LHA 032 - Hope		0.538	0.224	5.8	0.016	1.713	1.105	2.657
Age by Adherence	***0.001***							
30-39 by Low Adherence		-0.003	0.304	0.0	0.993	0.997	0.550	1.809
40-49 by Low Adherence		0.127	0.201	0.4	0.525	1.136	0.767	1.683
60-69 by Low Adherence		0.098	0.151	0.4	0.517	1.103	0.820	1.484
70-79 by Low Adherence		0.360	0.146	6.1	0.014	1.434	1.076	1.911
30-39 by High Adherence		0.430	0.311	1.9	0.167	1.537	0.835	2.829
40-49 by High Adherence		-0.064	0.193	0.1	0.739	0.938	0.643	1.368
60-69 by High Adherence		-0.260	0.128	4.1	0.043	0.771	0.599	0.992
70-79 by High Adherence		-0.302	0.128	5.6	0.018	0.739	0.576	0.949
Morbidity by Adherence	***0.035***							
Very Low by Low Adherence		17.773	3,686.4	0.0	0.996	52,339,057	0.000 .	
Very Low by High Adherence		18.302	3,686.4	0.0	0.996	88,779,150	0.000 .	
Low by Low Adherence		0.119	0.328	0.1	0.717	1.126	0.592	2.142
Low by High Adherence		0.290	0.369	0.6	0.431	1.337	0.649	2.754
High by Low Adherence		0.417	0.182	5.2	0.022	1.517	1.062	2.169
High by High Adherence		-0.228	0.185	1.5	0.217	0.796	0.554	1.143
Very High by Low Adherence		0.430	0.183	5.5	0.019	1.537	1.074	2.200
Very High by High Adherence		-0.081	0.180	0.2	0.653	0.922	0.648	1.312
SES by Sex	***0.027***							
Quintile 1 by Female		0.153	0.121	1.6	0.204	1.166	0.920	1.477
Quintile 2 by Female		0.093	0.121	0.6	0.440	1.098	0.866	1.392
Quintile 4 by Female		-0.229	0.125	3.4	0.067	0.795	0.622	1.016
Quintile 5 by Female		0.078	0.143	0.3	0.586	1.081	0.817	1.430

FITTED MODEL		
-2 log likelihood		15,653.3
Likelihood Ratio Test X^2		3,934.0
Degrees of Freedom		51
p - value		<0.001
Nagelkerke R Square		0.288
Hosmer & Lemeshow GOF		0.293

*Notes: ******* Reference Category*

4.12.3 Interpretation of the Final Fitted Model for Total Costs

After adjusting for the covariates and interactions in the model, the adherence variable just achieved statistical significance (p=0.049). This is in contrast to the individual models for physician and acute care costs in which the association between adherence and the probability of being in the high resource use category was strongly significant (p <0.001). In the analysis of physician costs, individuals in the low adherence category were less likely to incur high costs while those in the high adherence category were more likely to incur high costs. In the analysis of acute care costs, individuals in the low adherence category were more likely to incur high costs while those in the high adherence category were less likely to incur high costs. In the analysis of total costs, the acute care and physician costs were combined, so it is not surprising that the contrasting utilization patterns of the two almost cancelled each other out. In the total cost model, individuals in the low adherence category were 32.6% less likely (OR=0.674) than those in the medium adherence category (i.e., the reference group) to be in the high resource use category. Individuals in the high adherence, however, are no longer less likely to be in the high resource use category. By combining physician and acute care costs into total costs, clinically valuable insights regarding adherence and health care costs were lost.

After adjusting for the covariates in the model, females were significantly less likely (31.3%) to be in the high resource use category than men.

Age continued to be an important predictor of the probability of being in the high resource use category, even after adjusting for the other covariates in the model. Younger adults (i.e., aged 30-39 and 40-49) were 48.7% and 33.1%, respectively, less likely to be in the high resource use category compared to the reference group of 50-59 year olds. Those aged 60-69

were 37.5% more likely to be in the high resource use category. The elderly, aged 70-79 years of age were 135% more likely to be in the high resource use category than the reference group.

After adjusting for the covariates and interactions in the model, socio-economic status is no longer a significant variable (p=0.215).

The analysis confirmed that healthier patients incurred lower health care costs. Patients in the low morbidity group were 44.9% less likely to be in the high resource use group than are those in the medium morbidity group. The results for the very low morbidity group were non-significant as only six individuals in this category were in the high average annual total cost category. Adults in the high or very high morbidity groups remain dramatically more likely to be in the high resource use category (3.1 and 10.3 times, respectively).

Adults with no complications were significantly less likely (39.3%) to be in the high resource use group than those with one or more intermediate complications (i.e., the reference group). On the other hand, adults with one major or two or more major complications were 1.9 and 5.0 times, respectively, more likely to be in the high resource use category.

After adjusting for the covariates and interactions in the model, patients living in certain LHAs remained more likely to be in the high resource use category than those living in Surrey (i.e., the reference group). Individuals living in the LHAs of Hope (71.3%), New Westminster (40.0%), Maple Ridge (42.3%), Abbotsford (34.0%) and Langley (18.5%) were all more likely to be in the high resource use group than individuals who lived in Surrey.

The overall final model explained a significant proportion of the variation in the probability of being in the high average annual cost group with a Chi-square test statistic of 3,934.0 (51 *df*) which corresponded to a *p*-value of less than 0.001. The Nagelkerke R Square was 0.288, indicating that 28.8% of the total variance was accounted for by the model.

The goodness of fit of the multivariate model was assessed using the Hosmer & Lemeshow GOF test. The Hosmer & Lemeshow statistic was 9.6 with 8 *df* which was not statistically significant ($p = 0.293$) indicating that the model was an adequate fit for the observed data.

In summary, after adjusting for seven variables and the interactions between these variables (i.e., level of adherence, gender, age, socio-economic status, general morbidity, disease-specific morbidity, geographic location of residence), a number of patient characteristics predicted the likelihood of high versus low health care utilization, as defined by average annual total costs. Low health care costs were more likely in:

- individuals in the low adherence category
- females
- younger individuals
- those with a low level of co-morbidity
- those with no diabetes disease-specific complications

Higher health care costs were more likely in:

- males
- older individuals
- those with a high or very high level of co-morbidity
- those with one or more major diabetes disease-specific complications
- those living in the LHAs of Hope, Maple Ridge, New Westminster, Abbotsford and Langley

4.13 Analysis of Mean Annual Per Capita Physician and Acute Care Costs

The multivariate logistic regression analysis summarized above uncovered the importance of a number of patient characteristics in predicting the probability of high utilization of physician, acute care and total health care services. The patients general level of morbidity as measured by ACGs was consistently the most important variable in determining whether an adult with diagnosed type 2 diabetes was more or less likely to be in the high resource use category, whether for physician, acute care or total costs. Level of adherence to recommended clinical procedures was a strong predictor in determining the probability of being in the high resource use category for physician and acute care utilization, but less so for the total cost category. As noted earlier, this was likely due to the opposite influence of adherence on the probability of high acute care utilization. Adding physician and acute care costs into a total cost variable cancelled out these clinically relevant findings. Gender and age were important variables in the acute care and total cost models but less so in the physician cost model.

In the next sections, we will examine the average annual per capita physician and acute care costs in more detail taking into account the variables of general morbidity, adherence, gender and age.

4.13.1 Comparison of Annual Costs by Adherence and Morbidity

Table 4-47 provides summary information on the average annual per capita costs based on an individual's adherence and morbidity category. Mean annual per capita costs are subdivided into acute care costs and physician costs.

Table 4-47 Mean Annual Costs per Capita
By Level of Adherence and Level of Morbidity

Level of Morbidity →

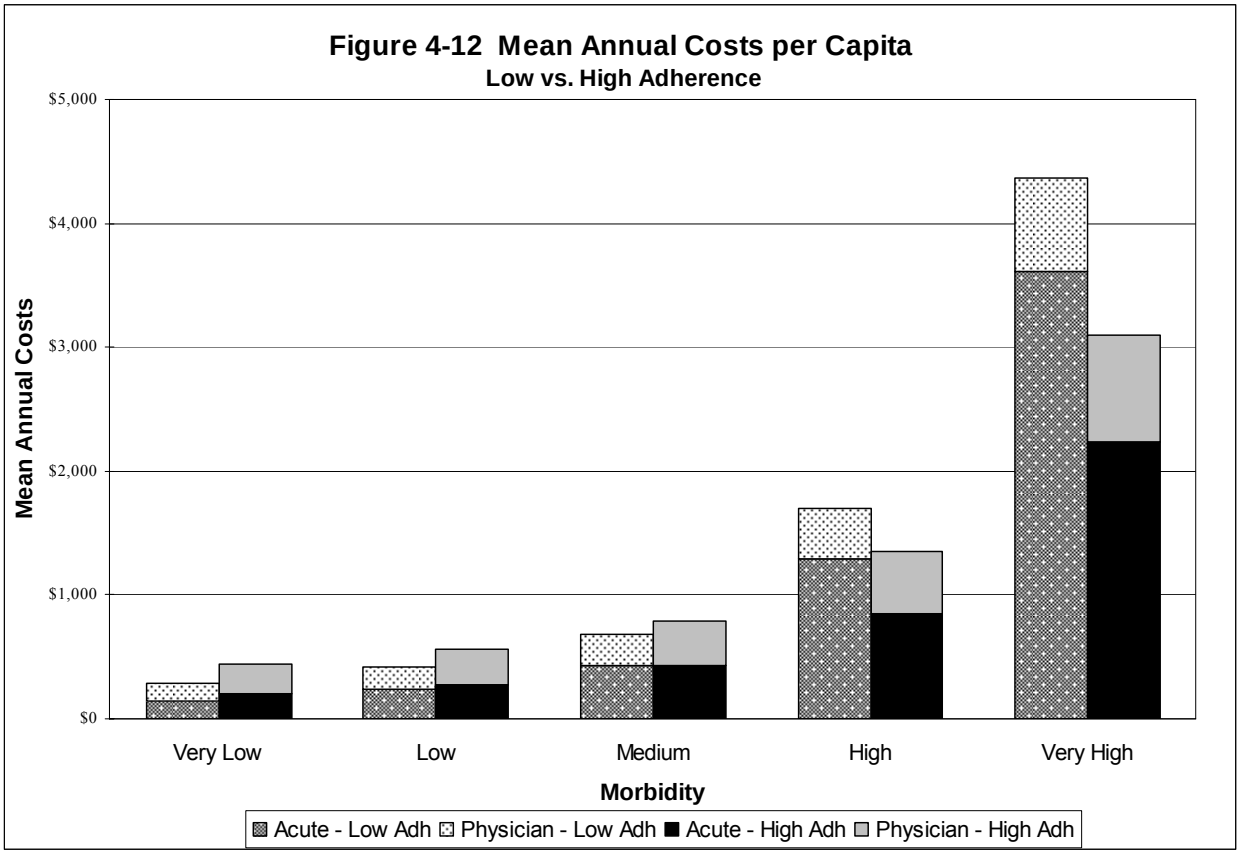
Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	177			928			1,419			1,596			954			5,136		
			Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
Low	*(0-9)*	Acute	*$148*	*$81*	*$216*	*$242*	*$175*	*$309*	*$428*	*$345*	*$511*	*$1,292*	*$1,150*	*$1,434*	*$3,616*	*$3,220*	*$4,011*	*$1,252*	*$1,157*	*$1,348*
		Physician	*$135*	*$124*	*$146*	*$176*	*$170*	*$183*	*$251*	*$243*	*$260*	*$404*	*$392*	*$417*	*$753*	*$725*	*$782*	*$378*	*$369*	*$387*
		Total	***$283***	***$209***	***$358***	***$419***	***$348***	***$489***	***$680***	***$592***	***$767***	***$1,696***	***$1,547***	***$1,845***	***$4,369***	***$3,956***	***$4,782***	***$1,630***	***$1,529***	***$1,732***
		N =	122			904			2,104			3,577			2,696			9,448		
Medium	*(10-14)*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$130*	*$71*	*$190*	*$256*	*$198*	*$315*	*$415*	*$368*	*$461*	*$1,054*	*$981*	*$1,127*	*$2,758*	*$2,585*	*$2,930*	*$1,310*	*$1,249*	*$1,371*
		Physician	*$184*	*$170*	*$199*	*$238*	*$231*	*$246*	*$315*	*$308*	*$322*	*$451*	*$442*	*$459*	*$791*	*$774*	*$808*	*$495*	*$488*	*$502*
		Total	***$315***	***$247***	***$382***	***$495***	***$432***	***$557***	***$730***	***$679***	***$780***	***$1,505***	***$1,427***	***$1,582***	***$3,549***	***$3,366***	***$3,732***	***$1,805***	***$1,739***	***$1,870***
		N =	35			354			977			2,276			1,972			5,644		
High	*(15-23)*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$200*	*-$33*	*$434*	*$274*	*$201*	*$346*	*$434*	*$355*	*$513*	*$849*	*$774*	*$923*	*$2,241*	*$2,091*	*$2,392*	*$1,226*	*$1,160*	*$1,291*
		Physician	*$245*	*$217*	*$272*	*$289*	*$276*	*$301*	*$358*	*$349*	*$368*	*$499*	*$488*	*$509*	*$855*	*$834*	*$876*	*$585*	*$575*	*$596*
		Total	***$445***	***$198***	***$692***	***$562***	***$483***	***$641***	***$792***	***$708***	***$876***	***$1,347***	***$1,267***	***$1,428***	***$3,096***	***$2,935***	***$3,258***	***$1,811***	***$1,740***	***$1,883***
		N =	334			2,186			4,500			7,449			5,622			20,228		
Total			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$147*	*$99*	*$195*	*$253*	*$214*	*$292*	*$423*	*$385*	*$461*	*$1,042*	*$991*	*$1,094*	*$2,722*	*$2,603*	*$2,842*	*$1,272*	*$1,230*	*$1,313*
		Physician	*$164*	*$155*	*$174*	*$220*	*$215*	*$225*	*$304*	*$300*	*$309*	*$455*	*$449*	*$461*	*$807*	*$795*	*$819*	*$491*	*$485*	*$496*
		Total	***$312***	***$259***	***$365***	***$473***	***$432***	***$515***	***$727***	***$687***	***$768***	***$1,498***	***$1,443***	***$1,552***	***$3,529***	***$3,403***	***$3,655***	***$1,762***	***$1,718***	***$1,807***

Note: *Included in the total by level of adherence are a number of people who were in the 'pregnancy' level of morbidity (88 in the low adherence group, 59 in the medium adherence group and 38 in the high adherence group.*

The average annual per capita physician costs increased with the level of adherence. That is, individuals in the low adherence category incurred, on average, $378 in physician costs per year compared to $495 for those in the medium adherence category and $585 for those in the high adherence category. This progression remained consistent regardless of the level of morbidity. Figure 4-12 provides a graphic comparison of mean annual physician and acute care costs per capita by morbidity level for the low and high adherence groups.

In the bottom three morbidity categories, there are no significant differences in annual acute care costs between the low and high adherence groups. This situation, however, changed significantly for individuals in the top two morbidity categories. When morbidity was high or very high, acute care costs were significantly higher in the low adherence group than in the high adherence group. Those in the low adherence group incurred, on average, $1,292 in acute care costs per year compared to $849 for those in the high adherence category. Individuals in the very high morbidity and low adherence group incurred, on average, $3,616 in acute care costs per

year compared to $2,241 for those in the high adherence category. Thus, even when patients were seriously ill, following the recommended clinical protocols for the treatment of diabetes reduced the acute care costs for this population. It should be noted that 65% (13,071) of the 20,228 people in this study population were in the high or very high morbidity categories.



4.13.2 Comparison of Annual Costs By Adherence, Morbidity and Gender

Table 4-48 provides summary information on the average annual costs per capita based on level of adherence and level of morbidity for females.

The average use of physician costs increases with the level of adherence. That is, females in the low adherence category incurred, on average, $427 in physician costs per year compared to $519 for those in the medium adherence category and $607 for those in the high adherence

category. This increased use of physician costs in the high vs. low adherence groups remained consistent regardless of the level of morbidity.

Table 4-48 Mean Annual Costs per Capita For Females
By Level of Adherence and Level of Morbidity

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	53			289			525			719			520			2,168		
			Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
Low	Acute		*$183*	*$22*	*$343*	*$301*	*$133*	*$468*	*$382*	*$250*	*$514*	*$1,424*	*$1,184*	*$1,665*	*$3,365*	*$2,836*	*$3,894*	*$1,445*	*$1,283*	*$1,608*
(0-9)	Physician		*$153*	*$131*	*$176*	*$181*	*$170*	*$192*	*$261*	*$246*	*$277*	*$416*	*$399*	*$433*	*$764*	*$725*	*$803*	*$427*	*$413*	*$442*
	Total		***$336***	***$165***	***$507***	***$482***	***$309***	***$654***	***$643***	***$504***	***$782***	***$1,840***	***$1,590***	***$2,090***	***$4,129***	***$3,576***	***$4,682***	***$1,873***	***$1,701***	***$2,044***
		N =	40			327			898			1,645			1,363			4,318		
Medium			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
(10-14)	Acute		*$98*	*-$5*	*$202*	*$263*	*$140*	*$386*	*$397*	*$324*	*$469*	*$967*	*$861*	*$1,072*	*$2,616*	*$2,367*	*$2,866*	*$1,309*	*$1,215*	*$1,403*
	Physician		*$196*	*$172*	*$220*	*$238*	*$227*	*$249*	*$325*	*$314*	*$335*	*$450*	*$439*	*$461*	*$800*	*$776*	*$825*	*$519*	*$508*	*$530*
	Total		***$295***	***$175***	***$415***	***$501***	***$374***	***$628***	***$721***	***$644***	***$799***	***$1,417***	***$1,305***	***$1,528***	***$3,417***	***$3,153***	***$3,681***	***$1,827***	***$1,726***	***$1,929***
		N =	16			131			421			1,113			1,059			2,770		
High			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
(15-23)	Acute		*$36*	*-$19*	*$91*	*$184*	*$91*	*$278*	*$428*	*$325*	*$532*	*$791*	*$678*	*$905*	*$1,934*	*$1,754*	*$2,114*	*$1,145*	*$1,058*	*$1,233*
	Physician		*$246*	*$206*	*$286*	*$283*	*$260*	*$306*	*$362*	*$347*	*$377*	*$504*	*$489*	*$520*	*$852*	*$824*	*$881*	*$607*	*$592*	*$622*
	Total		***$282***	***$206***	***$357***	***$467***	***$364***	***$571***	***$791***	***$679***	***$902***	***$1,296***	***$1,173***	***$1,418***	***$2,787***	***$2,591***	***$2,982***	***$1,752***	***$1,655***	***$1,849***
		N =	109			747			1,844			3,477			2,942			9,256		
Total			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
	Acute		*$130*	*$44*	*$216*	*$264*	*$178*	*$349*	*$400*	*$343*	*$456*	*$1,005*	*$926*	*$1,085*	*$2,503*	*$2,340*	*$2,666*	*$1,292*	*$1,228*	*$1,356*
	Physician		*$183*	*$167*	*$199*	*$224*	*$216*	*$232*	*$315*	*$307*	*$323*	*$460*	*$452*	*$468*	*$813*	*$796*	*$829*	*$524*	*$516*	*$531*
	Total		***$313***	***$220***	***$406***	***$488***	***$399***	***$576***	***$715***	***$655***	***$775***	***$1,466***	***$1,382***	***$1,549***	***$3,316***	***$3,144***	***$3,488***	***$1,815***	***$1,747***	***$1,884***

Note: *Included in the total by level of adherence are a number of people in the 'pregnancy' level of morbidity (62 in the low adherence group, 45 in the medium adherence group and 30 in the high adherence group.*

In the bottom three morbidity categories, there were no significant differences in annual acute care costs between the low and high adherence categories. The pattern was markedly different for females in the top two morbidity groups. In both of these groups, acute care costs were significantly higher in the low adherence group than in the high adherence group. Females in the low adherence group used, on average, $1,424 in acute care services per year compared to $791 for females in the high adherence category. High acute care costs were most apparent in females with very high morbidity and low adherence. Females in this group used, on average, $3,365 in acute care services per year compared to $1,934 for those in the high adherence category.

Figures 4-13 provides a graphic comparison of resource use by morbidity level for the female low and high adherence groups.

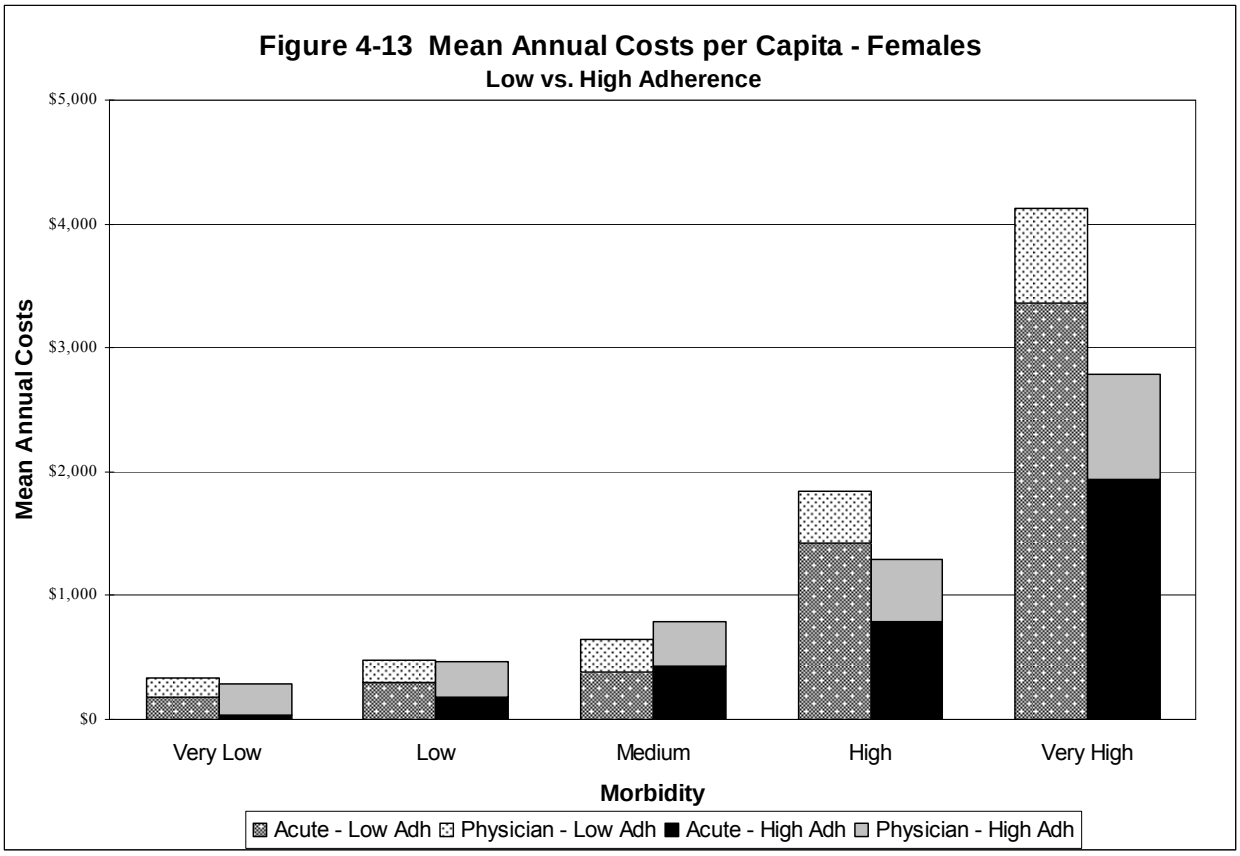


Figure 4-13 Mean Annual Costs per Capita - Females
Low vs. High Adherence
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Mean Annual Costs
Very Low
Low
Medium
High
Very High
Morbidity
Acute - Low Adh
Physician - Low Adh
Acute - High Adh
Physician - High Adh

Table 4-49 provides summary information on the average annual costs per capita based on level of adherence and level of morbidity for males.

Table 4-49 Mean Annual Costs per Capita For Males
By Level of Adherence and Level of Morbidity

Level of Morbidity →

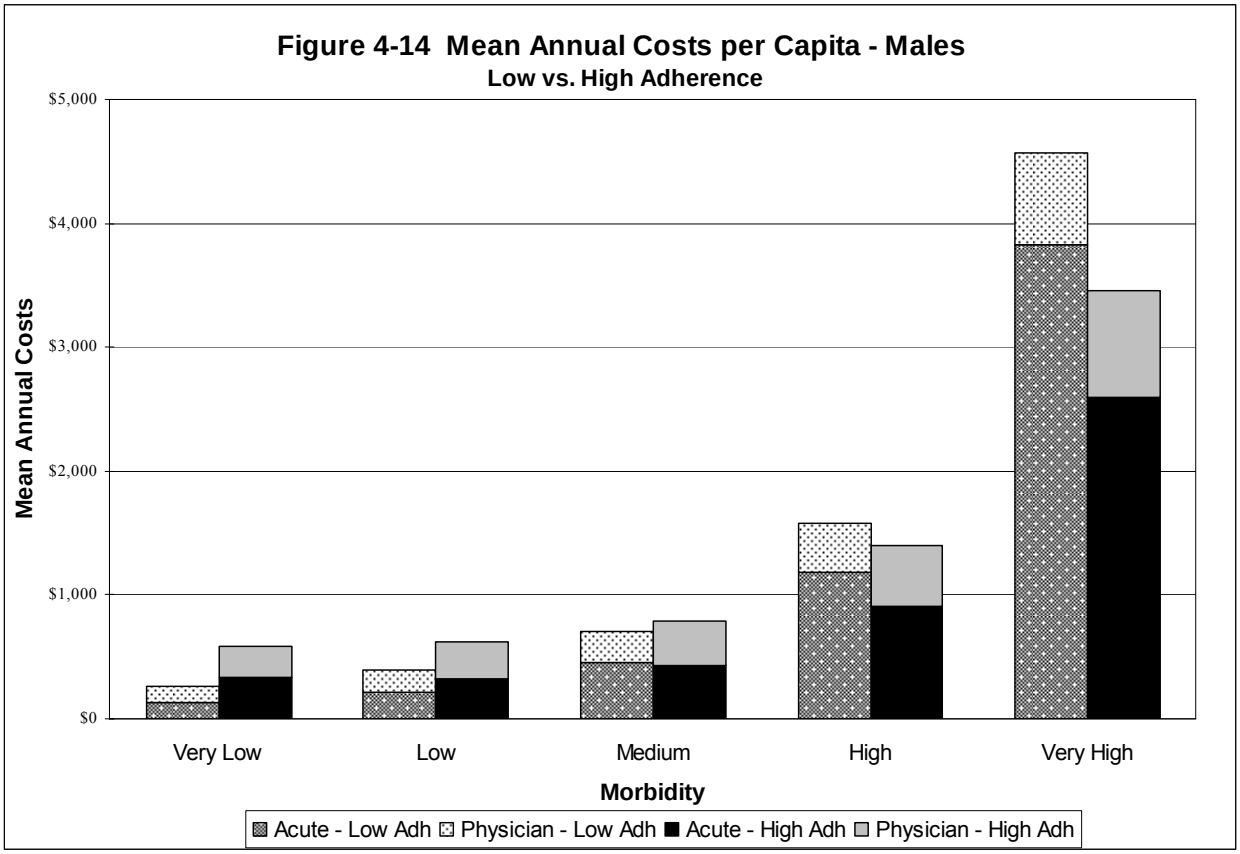
Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	123			634			890			873			431			2,951		
			Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
Low	*(0-9)*	Acute	*$135*	*$64*	*$205*	*$216*	*$154*	*$278*	*$456*	*$349*	*$563*	*$1,185*	*$1,018*	*$1,353*	*$3,833*	*$3,257*	*$4,409*	*$1,100*	*$988*	*$1,212*
		Physician	*$127*	*$114*	*$140*	*$174*	*$166*	*$183*	*$245*	*$236*	*$255*	*$395*	*$378*	*$413*	*$736*	*$695*	*$776*	*$341*	*$330*	*$352*
		Total	***$262***	***$182***	***$342***	***$390***	***$323***	***$457***	***$701***	***$589***	***$814***	***$1,581***	***$1,402***	***$1,759***	***$4,569***	***$3,970***	***$5,167***	***$1,441***	***$1,322***	***$1,560***
		N =	81			575			1,198			1,925			1,327			5,106		
Medium	*(10-14)*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$147*	*$73*	*$222*	*$240*	*$186*	*$294*	*$422*	*$362*	*$482*	*$1,132*	*$1,031*	*$1,234*	*$2,903*	*$2,664*	*$3,142*	*$1,310*	*$1,230*	*$1,389*
		Physician	*$180*	*$161*	*$198*	*$238*	*$228*	*$249*	*$307*	*$299*	*$316*	*$451*	*$438*	*$464*	*$782*	*$758*	*$806*	*$475*	*$465*	*$485*
		Total	***$327***	***$242***	***$412***	***$478***	***$418***	***$539***	***$729***	***$664***	***$794***	***$1,584***	***$1,476***	***$1,691***	***$3,685***	***$3,431***	***$3,938***	***$1,785***	***$1,699***	***$1,871***
		N =	19			222			553			1,155			911			2,860		
High	*(15-23)*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$339*	*-$98*	*$776*	*$328*	*$226*	*$429*	*$436*	*$320*	*$552*	*$906*	*$808*	*$1,003*	*$2,597*	*$2,350*	*$2,844*	*$1,305*	*$1,208*	*$1,402*
		Physician	*$244*	*$202*	*$286*	*$292*	*$278*	*$307*	*$356*	*$343*	*$369*	*$493*	*$480*	*$507*	*$857*	*$828*	*$887*	*$565*	*$552*	*$579*
		Total	***$583***	***$121***	***$1,044***	***$620***	***$510***	***$730***	***$792***	***$670***	***$914***	***$1,399***	***$1,293***	***$1,504***	***$3,454***	***$3,190***	***$3,718***	***$1,870***	***$1,765***	***$1,976***
		N =	223			1,431			2,641			3,953			2,669			10,917		
Total			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$157*	*$98*	*$215*	*$243*	*$204*	*$281*	*$436*	*$385*	*$488*	*$1,078*	*$1,010*	*$1,146*	*$2,948*	*$2,775*	*$3,122*	*$1,252*	*$1,197*	*$1,306*
		Physician	*$156*	*$145*	*$167*	*$218*	*$212*	*$225*	*$297*	*$291*	*$303*	*$451*	*$443*	*$460*	*$800*	*$783*	*$817*	*$463*	*$456*	*$469*
		Total	***$313***	***$248***	***$378***	***$461***	***$419***	***$503***	***$733***	***$679***	***$787***	***$1,529***	***$1,457***	***$1,601***	***$3,749***	***$3,566***	***$3,932***	***$1,714***	***$1,656***	***$1,773***

The average physician costs increased with the level of adherence. That is, males in the low adherence category incurred, on average, $341 of physician resources per year compared to $475 for those in the medium adherence category and $565 for those in the high adherence category. This increased level of physician costs in the high vs. low adherence groups remained consistent regardless of the level of morbidity.

In the bottom three morbidity categories, there were no significant differences in annual acute care costs between the low and high adherence categories. As with females, the pattern was dramatically different for males in the high and very high morbidity groups. In both of these groups, acute care costs were significantly higher in the low adherence group than in the high adherence group. Males in the low adherence group incurred, on average, $1,185 in acute care costs per year compared to $906 for those in the high adherence category. Males with low

adherence who were in the very high morbidity group incurred, on average, $3,833 in acute care costs per year compared to $2,597 for with high adherence category.

Figure 4-14 provides a graphic comparison of resource use by morbidity level for the male low and high adherence groups.



4.13.3 Comparison of Annual Costs By Adherence, Morbidity and Age

Table 4-50 provides summary information on the average annual costs per capita based on level of adherence and level of morbidity for individuals from 30 to 59 years of age.

The average use of physician costs increased with the level of adherence. That is, younger individuals (aged 30-59) in the low adherence category incurred, on average, $336 in physician costs per year compared to $475 for those in the medium adherence category and $607

for those in the high adherence category. This increased level of physician costs in the high vs. low adherence groups remained consistent regardless of the level of morbidity.

Table 4-50 Mean Annual Costs per Capita For Ages 30-59
By Level of Adherence and Level of Morbidity

Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	113			543			829			764			412			2,722		
			Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Low	Acute		$117	$41	$193	$160	$101	$219	$273	$201	$346	$717	$584	$851	$2,600	$1,991	$3,209	$736	$629	$843
(0-9)	Physician		$124	$111	$138	$163	$155	$171	$240	$229	$251	$367	$350	$385	$726	$681	$772	$336	$324	$347
	Total		**$241**	**$156**	**$326**	**$323**	**$260**	**$386**	**$514**	**$436**	**$591**	**$1,085**	**$942**	**$1,227**	**$3,326**	**$2,691**	**$3,961**	**$1,072**	**$958**	**$1,185**
		N =	60			459			1,019			1,530			1,011			4,123		
Medium			Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
(10-14)	Acute		$104	$35	$172	$159	$105	$214	$314	$253	$374	$662	$585	$739	$1,935	$1,697	$2,173	$829	$759	$899
	Physician		$176	$156	$195	$230	$218	$242	$312	$302	$323	$448	$432	$464	$800	$769	$832	$475	$463	$487
	Total		**$279**	**$199**	**$359**	**$390**	**$327**	**$452**	**$626**	**$559**	**$692**	**$1,110**	**$1,025**	**$1,194**	**$2,735**	**$2,478**	**$2,993**	**$1,304**	**$1,226**	**$1,381**
		N =	10			133			401			819			693			2,085		
High			Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
(15-23)	Acute		$74	-$38	$185	$228	$121	$336	$341	$211	$471	$620	$501	$740	$1,822	$1,590	$2,054	$948	$850	$1,046
	Physician		$244	$179	$309	$295	$271	$319	$363	$348	$378	$509	$489	$528	$924	$881	$967	$607	$588	$627
	Total		**$318**	**$156**	**$479**	**$523**	**$402**	**$644**	**$704**	**$566**	**$841**	**$1,129**	**$997**	**$1,261**	**$2,746**	**$2,491**	**$3,001**	**$1,555**	**$1,445**	**$1,665**
		N =	183			1,135			2,249			3,113			2,116			8,930		
Total			Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
	Acute		$110	$58	$162	$168	$130	$206	$304	$259	$348	$664	$605	$724	$2,028	$1,847	$2,208	$828	$777	$880
	Physician		$148	$136	$159	$205	$198	$213	$295	$288	$302	$444	$434	$454	$826	$804	$849	$463	$455	$472
	Total		**$258**	**$199**	**$317**	**$373**	**$331**	**$415**	**$598**	**$550**	**$647**	**$1,109**	**$1,044**	**$1,173**	**$2,854**	**$2,661**	**$3,047**	**$1,292**	**$1,236**	**$1,348**

Level of Morbidity

Note: *Included in the total by level of adherence are a number of people in the 'pregnancy' level of morbidity (61 in the low adherence group, 44 in the medium adherence group and 29 in the high adherence group.*

There were no significant differences in annual acute care costs between the low and high adherence categories based on level of morbidity for younger individuals.

Figures 4-15 provides a graphic comparison of resource use by morbidity level for younger individuals in the low and high adherence groups.

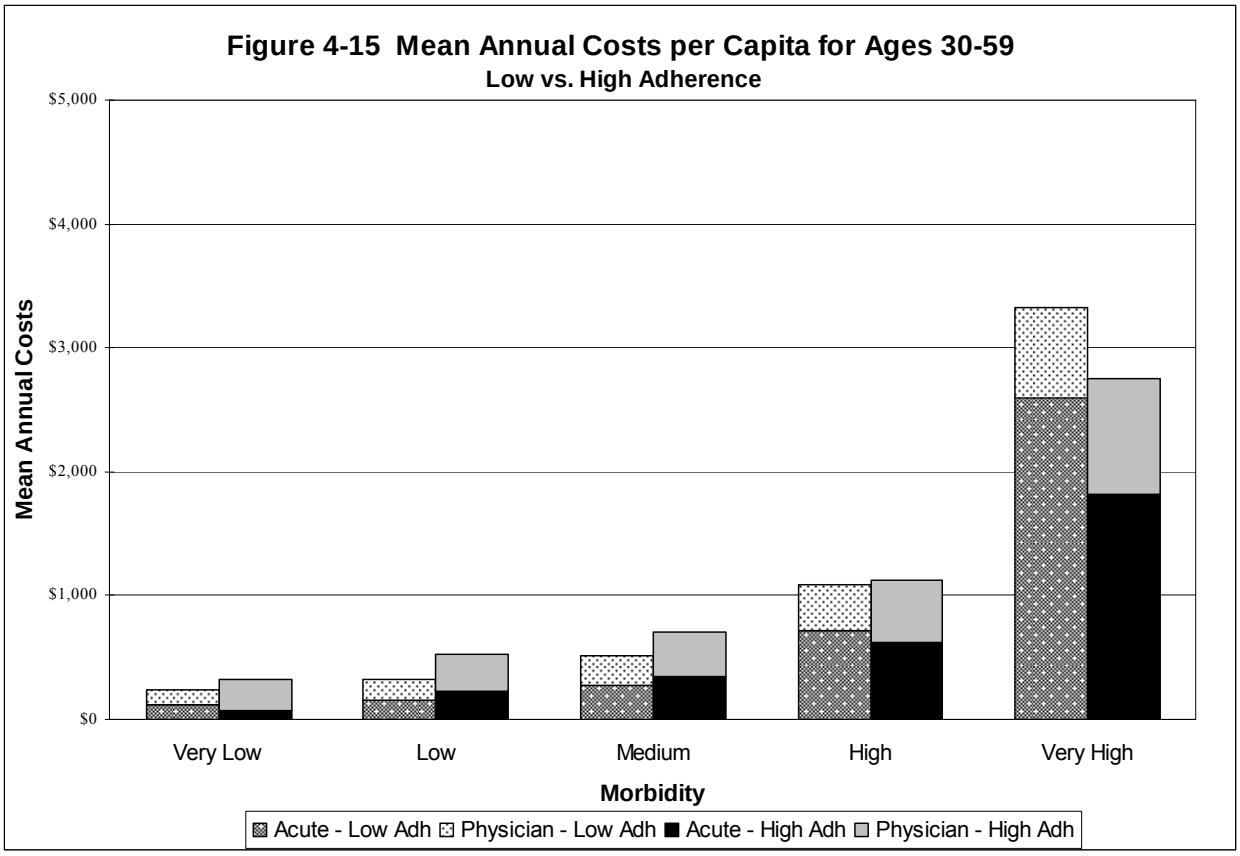


Figure 4-15 Mean Annual Costs per Capita for Ages 30-59
Low vs. High Adherence
Mean Annual Costs
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Very Low
Low
Medium
High
Very High
Morbidity
Acute - Low Adh
Physician - Low Adh
Acute - High Adh
Physician - High Adh

Table 4-51 provides summary information on the average annual costs per capita based on level of adherence and level of morbidity for individuals from 60 to 79 years of age.

Table 4-51 Mean Annual Costs per Capita For Ages 60-79
By Level of Adherence and Level of Morbidity

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	64			385			590			832			542			2,414		
			Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
Low	*(0-9)*	Acute	*$204*	*$71*	*$337*	*$358*	*$220*	*$496*	*$646*	*$475*	*$816*	*$1,820*	*$1,582*	*$2,058*	*$4,388*	*$3,876*	*$4,900*	*$1,835*	*$1,675*	*$1,995*
		Physician	*$154*	*$134*	*$173*	*$196*	*$183*	*$208*	*$267*	*$255*	*$280*	*$438*	*$421*	*$456*	*$774*	*$738*	*$810*	*$426*	*$412*	*$439*
		Total	***$358***	***$215***	***$501***	***$554***	***$410***	***$698***	***$913***	***$735***	***$1,090***	***$2,258***	***$2,010***	***$2,507***	***$5,162***	***$4,627***	***$5,697***	***$2,260***	***$2,091***	***$2,430***
		N =	62			445			1,085			2,047			1,685			5,325		
Medium			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
	(10-14)	Acute	*$156*	*$58*	*$254*	*$356*	*$252*	*$460*	*$509*	*$440*	*$579*	*$1,347*	*$1,235*	*$1,460*	*$3,251*	*$3,098*	*$3,485*	*$1,682*	*$1,590*	*$1,774*
		Physician	*$193*	*$171*	*$215*	*$247*	*$238*	*$256*	*$318*	*$309*	*$326*	*$453*	*$443*	*$462*	*$786*	*$766*	*$806*	*$510*	*$501*	*$520*
		Total	***$349***	***$238***	***$459***	***$603***	***$495***	***$711***	***$827***	***$753***	***$901***	***$1,800***	***$1,682***	***$1,918***	***$4,037***	***$3,791***	***$4,283***	***$2,193***	***$2,094***	***$2,291***
		N =	25			221			576			1,457			1,279			3,559		
High			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
	(15-23)	Acute	*$251*	*-$79*	*$581*	*$301*	*$204*	*$398*	*$498*	*$399*	*$597*	*$977*	*$883*	*$1,071*	*$2,469*	*$2,275*	*$2,662*	*$1,388*	*$1,303*	*$1,474*
		Physician	*$245*	*$213*	*$277*	*$285*	*$271*	*$299*	*$355*	*$343*	*$368*	*$493*	*$481*	*$504*	*$818*	*$796*	*$839*	*$573*	*$562*	*$584*
		Total	***$496***	***$150***	***$842***	***$586***	***$482***	***$690***	***$854***	***$748***	***$959***	***$1,470***	***$1,369***	***$1,571***	***$3,286***	***$3,080***	***$3,493***	***$1,961***	***$1,868***	***$2,054***
		N =	151			1,051			2,251			4,336			3,506			11,298		
Total			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
		Acute	*$192*	*$107*	*$278*	*$345*	*$275*	*$415*	*$542*	*$481*	*$604*	*$1,314*	*$1,236*	*$1,391*	*$3,142*	*$2,986*	*$3,297*	*$1,622*	*$1,561*	*$1,684*
		Physician	*$185*	*$171*	*$199*	*$236*	*$229*	*$243*	*$314*	*$308*	*$320*	*$463*	*$457*	*$470*	*$796*	*$782*	*$809*	*$512*	*$506*	*$518*
		Total	***$377***	***$285***	***$469***	***$581***	***$508***	***$654***	***$856***	***$792***	***$921***	***$1,777***	***$1,696***	***$1,858***	***$3,937***	***$3,773***	***$4,101***	***$2,134***	***$2,068***	***$2,200***

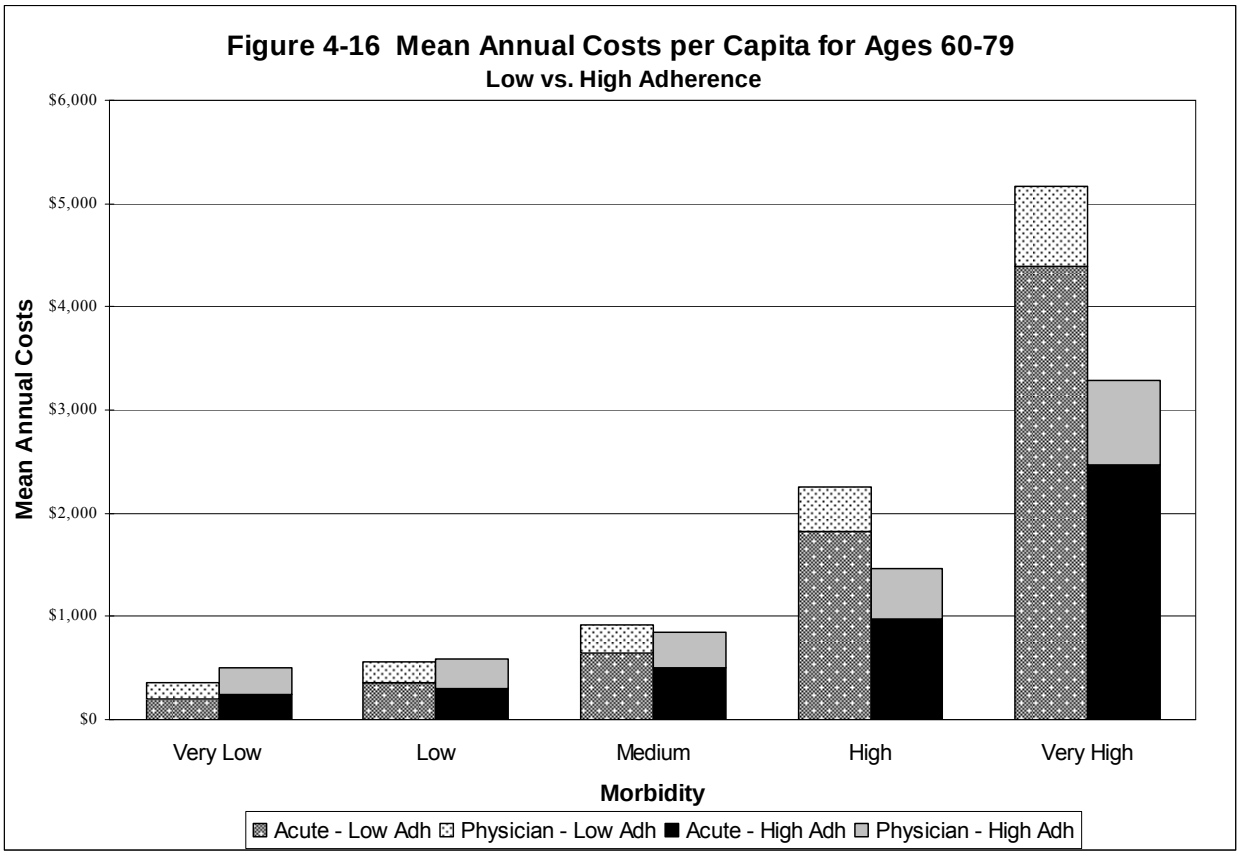
Note: *Included in the total by level of adherence are a number of people in the 'pregnancy' level of morbidity (1 in the low adherence group, 1 in the medium adherence group and 1 in the high adherence group.*

The average physician costs increased with the level of adherence. That is, older individuals (ages 60-79) in the low adherence category incurred, on average, $426 (95% CI of $412, $439) in physician costs per year compared to $510 (95% CI of $501, $520) for those in the medium adherence category and $573 (95% CI of $562, $584) for those in the high adherence category. This increased level of physician costs in the high vs. low adherence groups remained consistent regardless of the level of morbidity, with the exception of those in the very high morbidity group. In this category, there were no significant difference in the average annual physician costs between individuals in the low ($774) and high ($818) adherence groups.

In the bottom three morbidity categories, there were no significant differences in annual acute care costs between the low and high adherence categories. This pattern was markedly different for older individuals in the high and very high morbidity groups. In both of these

groups, acute care costs were significantly higher in the low adherence group than in the high adherence group. Older individuals with low adherence who were in the high morbidity incurred, on average, $1,820 in acute care costs per year compared to $977 for those in the high adherence category. Similarly, those with low adherence who were in the very high morbidity incurred, on average, $4,388 in acute care costs compared to $2,469 for those in the high adherence category.

Figures 4-16 provides a graphic comparison of resource use by morbidity level for older individuals in the low and high adherence groups.



4.13.4 Utilization of Acute Care Services By Older Adults with High Morbidity

The most important difference in acute care costs associated with being in the high or low adherence groups occurred in older adults (i.e., aged 60-79) in the high or very high morbidity categories. When comparing the low and high adherence groups, average per capita annual acute care costs were 86% higher ($1,820 vs. $977) in the high morbidity group and 76% higher ($4,338 vs. $2,469) in the very high morbidity group for those in the low adherence category. Of the total study population, 7,842 individuals (37% of 20,288) were older adults with high or very high morbidity categories.

In this section we analyse differences in acute care utilization between the low and high adherence groups (for older adults in the high and very high morbidity categories) to determine the key drivers of these cost differences.

Table 4-52 provides an analysis of the individuals who were hospitalized during the study period. During the five years from April 1, 1996 to March 31, 2001, a total of 64.3% (95% CI of 61.8%, 66.8%) of individuals in the low adherence group were hospitalized compared to 55.8% (95% CI of 54.0%, 57.7%) in the high adherence group. The proportion of individuals hospitalized in any given year ranged from a low of 16.1% (i.e., in 1996/97 for the high adherence group) to a high of 29.8% (i.e., in 1999/00 for the low adherence group). The proportion of the study population which was hospitalised was consistently lower for the high adherence group, though this difference achieves statistical significance only during the three middle years (i.e., 1997/98, 1998/99, 1999/00).

For both the high and low adherence group, the proportion hospitalized appears to decrease in the final year (2000/01) after four years of consecutive increases. In the low adherence group, the proportion hospitalized increased from 18.7% in 1996/97 to 29.8% in

1999/00 before declining to 22.1% in 2000/01. The decrease observed in 2000/01 may be due to incompleteness of data for the final year of study. Specifically, a hospital stay in any given year is only identified once the patient is discharged from hospital. Thus, patients who were admitted near the end of the 2000/01 fiscal year but who were not discharged by March 31, 2001 could not be identified. This only applies to the 2000/01 year and appears to differentially affect individuals in the low adherence group, perhaps due to their longer average hospital stay than patients in the high adherence group (see below).

Table 4-52 Utilization of Acute Care Services
By Adults Aged 60 - 79 with Diagnosed Type 2 Diabetes
In the High or Very High Morbidity Groups

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Pecent Hospitalized																		
Low Adherence *(N=1,374)*	18.7%	16.7%	20.9%	20.9%	18.8%	20.9%	27.4%	25.1%	29.8%	29.8%	27.5%	32.3%	22.1%	19.9%	24.3%	**64.3%**	**61.8%**	**66.8%**
High Adherence *(N=2,736)*	16.1%	14.8%	17.6%	17.1%	15.7%	18.5%	20.4%	19.0%	22.0%	20.9%	19.4%	22.5%	20.0%	18.5%	21.5%	**55.8%**	**54.0%**	**57.7%**

Hospitalized Cohort

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Low Adherence																		
# Hospitalized	257			287			376			410			303			884		
Discharges	1.67	1.52	1.82	1.67	1.53	1.81	1.52	1.42	1.62	1.63	1.52	1.74	1.68	1.55	1.82	0.60	0.56	0.64
Patient Days	18.39	14.33	22.46	16.53	13.82	19.24	17.33	14.41	20.24	21.05	17.79	24.31	22.99	18.06	27.92	7.15	6.45	7.85
ALOS	11.01			9.90			11.40			12.91			13.68			11.92		
Estimated Cost																		
Acute Care Inpatient	$ 11,066	8,705	13,427	10,388	8,658	12,117	10,572	9,030	12,115	11,708	10,282	13,134	12,844	10,458	15,230	4,184	3,822	4,546
Cost per Day	$ 602			628			610			556			559			585		
High Adherence																		
# Hospitalized	441			467			559			572			546			1,528		
Discharges	1.42	1.35	1.49	1.52	1.42	1.61	1.47	1.39	1.55	1.44	1.37	1.51	1.54	1.45	1.63	0.50	0.48	0.52
Patient Days	8.15	7.24	9.06	9.29	8.18	10.41	8.48	7.50	9.46	10.33	8.98	11.67	12.56	10.74	14.38	3.33	3.08	3.58
ALOS	5.74			6.11			5.77			7.17			8.16			6.66		
Estimated Cost																		
Acute Care Inpatient	$ 6,527	5,910	7,143	7,814	6,917	8,711	7,011	6,333	7,689	7,897	7,152	8,641	9,219	7,977	10,460	2,617	2,453	2,782
Cost per Day	$ 801			841			827			764			734			786		

Costs are in constant 2000/01 Canadian dollars

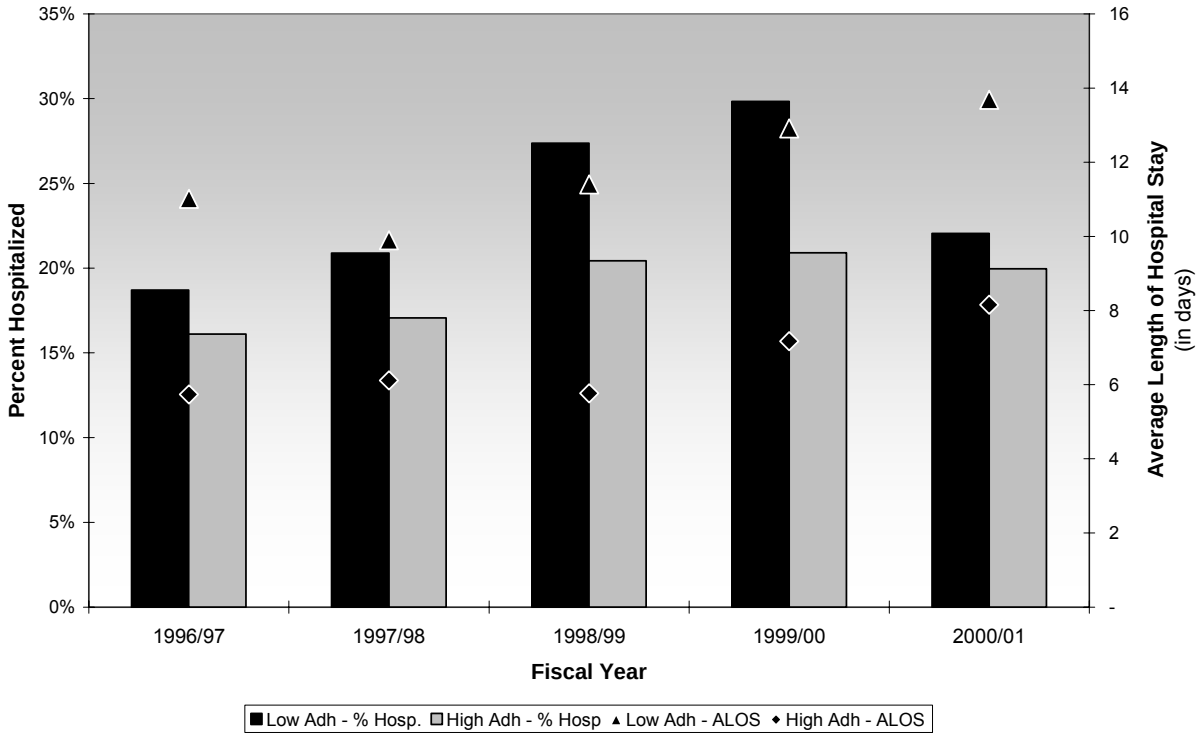
Table 4-52 also provides a summary of the hospital discharges, average length of stay[14] and costs[15] for the hospitalized cohort only. As noted earlier, individuals in the high adherence category were consistently less likely to be hospitalized than individuals in the low adherence category. The analysis revealed that when individuals in the high adherence category were

[14] The average length of stay (ALOS) was calculated by dividing the mean patient days for the hospitalized cohort by the mean hospital discharges for the same cohort.

[15] The mean acute care inpatient costs were calculated based on the total hospital costs for the hospitalized cohort in the given year (or the average over the five year period) divided by the number of individuals in the hospitalized cohort. The cost per day was calculated by dividing the mean hospital cost for the hospitalized cohort by the ALOS for the same cohort.

hospitalized, they tended to stay for a shorter period of time. During the five year study period, the average length of stay for hospitalized patients in the high adherence category was 6.66 days compared to 11.92 days for patients in the low adherence category. This difference in average length of stay (ALOS) is consistent during each of the five years, as shown graphically in figure 4-17.

Figure 4-17 Adults Aged 60-79 with Diagnosed Type 2 Diabetes
In the High or Very High Morbidity Groups
Proportion Hospitalized and ALOS



In this analysis of hospitalization, individuals in the high adherence category were both less likely to be hospitalized and, when they were hospitalized, tended to stay in hospital for shorter periods of time. As depicted above, this resulted in overall lower acute care costs for those in the high adherence group compared to the low adherence group.

4.14 Summary of Key Results

This summary is structured based on the key aims set out at the beginning of the study.

Aim 1: To determine whether adherence to recommended clinical procedures for adults with diagnosed type 2 diabetes living within the geographic boundaries of the Fraser Health Authority has changed during the five years from April 1, 1996 to March 31, 2001.

The proportion of patients receiving the recommended clinical procedures increased between 1996/97 and 2000/01 as follows:

- From 35% to 52% for two or more HbA1c tests per year
- From 36% to 39% for at least one eye exam per year
- From 13% to 38% for at least one urinary microalbumin test per year
- From 77% to 82% for at least one lipid test every three years
- From 81% to 85% for at least four BP measurements per year

In addition, the proportion of patients who received all five tests in a given year increased from 3.9% to 10.7% while the proportion of patients receiving none of the services in a given year decreased from 3.0% to 2.2%. These positive trends were seen for individuals in both the low and high adherence groups.

While these trends are encouraging, the fact is that during the entire five year study period, just 53% of recommended clinical procedures were received by patients.

Aim 2: To determine which patient characteristics are associated with improved long-term adherence to recommended clinical procedures.

Individuals in the high adherence category received, on average, 67.3% of recommended clinical procedures during the five year study period while those in the low adherence category received 40.0%.[16]

Based on the multivariate analysis, the following patient characteristics were associated with being in the high or low long-term adherence category (see also table 4-54 below):

Table 4-53: Patient Characteristics Associated with High or Low Adherence

Patient Characteristic	High Adherence	Low Adherence
Gender	Female	Male
Age	Older	Younger
Socio-economic status		Low (Quintile 1)
General morbidity	High or very high	
Disease-specific severity		No complications
Patient residence	South Surrey / White Rock Burnaby Langley	Mission Maple Ridge Abbotsford

[16] In this section, low and high adherence is based on adherence as a binary variable.

Table 4-54 Summary of Odds Ratios for
Adherence and High Average Annual Cost Categories

	OR for Being in the High Adherence Category		***Odds Ratio for Being in the High Average Annual Cost Category***					
			Physician		**Acute Care**		**Total**	
	Bi-Variate	*Multi-Variate*	*Bi-Variate*	*Multi-Variate*	*Bi-Variate*	*Multi-Variate*	*Bi-Variate*	*Multi-Variate*
By Level of Adherence								
Low			0.588	0.721	0.778	1.173	0.750	0.674
Medium			*******					
High			1.540	1.587	NS	0.779	NS	NS
By Sex								
Female	1.203	1.336	1.340	NS	NS	0.737	NS	0.687
Male	*******		*******					
By Age *(in Year 3)*								
30-39	0.583	0.646	NS	NS	0.669	0.566	0.677	0.513
40-49	0.764	0.830	NS	NS	0.661	0.662	0.675	0.669
50-59	*******		*******					
60-69	1.403	1.428	NS	0.685	1.540	1.440	1.430	1.375
70-79	1.268	1.248	1.632	NS	2.865	2.476	2.730	2.348
By Socio-Economic Status (in Year 3)								
Quintile 1 (Low)	NS	0.899	1.495	1.416	1.289	NS	1.370	NS
Quintile 2	NS	NS	1.169	1.185	1.143	NS	1.144	NS
Quintile 3	*******		*******					
Quintile 4	NS	NS	NS	NS	NS	NS	NS	NS
Quintile 5 (High)	NS	NS	NS	NS	NS	NS	NS	NS
By Morbidity								
Very Low	0.409	NS	NS	NS	0.368	0.394	0.314	NS
Low	0.643	NS	0.218	0.244	0.637	0.653	0.592	0.551
Medium	*******		*******					
High	1.548	1.542	4.810	4.178	3.240	2.964	3.544	3.075
Very High	2.006	1.984	36.670	29.729	10.580	9.330	12.874	10.277
By Disease-Specific Severity Index								
No Complications	0.406	0.622	0.254	0.515	0.283	0.641	0.266	0.607
1 or More Minor Comp.	0.616	NS	0.558	0.768	0.583	NS	0.580	NS
1 or More Intermediate Comp.	*******		*******					
1 Major Comp.	NS	NS	1.497	NS	2.039	2.092	1.983	1.929
2 or More Major Comp.	NS	NS	3.513	1.980	5.691	6.184	5.084	5.031
By Patient Residence (in Year 3)								
LHA 202 - S. Surrey / WR	1.361	1.268	0.817	NS	1.338	NS	1.252	NS
LHA 201 - Surrey	*******		*******					
LHA 076 - Agassiz-Harrison	NS	NS	NS	0.078	NS	NS	NS	NS
LHA 075 - Mission	0.757	0.764	NS	NS	NS	1.283	NS	NS
LHA 043 - Coquitlam	NS	NS	0.706	NS	NS	1.175	NS	NS
LHA 042 - Maple Ridge	0.767	0.782	NS	NS	1.318	1.376	1.289	1.423
LHA 041 - Burnaby	1.380	1.383	0.806	0.870	NS	NS	0.882	NS
LHA 040 - New Westminster	1.177	NS	NS	NS	1.432	1.410	1.395	1.400
LHA 037 - Delta	NS	NS	NS	1.300	NS	NS	NS	NS
LHA 035 - Langley	1.453	1.373	0.734	0.653	1.370	1.301	1.245	1.185
LHA 034 - Abbotsford	0.839	0.819	0.788	NS	1.362	1.394	1.267	1.340
LHA 033 - Chilliwack	NS	NS	0.779	0.688	1.420	1.267	1.303	NS
LHA 032 - Hope	NS	NS	1.486	NS	2.189	1.793	1.885	1.713

Notes:

******* *Reference Category*

NS=Not Significant

Aim 3: **To determine whether the utilization of physician and acute care services has changed during the five year study period.**

The average annual number of physician visits (i.e., including both general practitioner and specialist) increased from 11.6 in 1996/97 to 13.2 in 2000/01, an increase of 13.9%. The cost of these visits increased from $436 to $535 (22.8%).

The average annual number of hospitalizations increased from 0.19 to 0.23 (21.1%) while the number of patient days increased from 1.25 to 2.13 (70.4%). Average annual acute care costs (both inpatient and surgical day care) increased from $1,013 to $1,605 (58.4%).

Average annual total costs increased from $1,449 to $2,140, an increase of 47.7%.

While the increases in annual physician, acute care and total costs from the beginning to the end of the study period were substantial, it should be remembered that this is a cohort study in which the same subjects were assessed during the entire time period. Thus they were both older and their diabetes had progressed from the beginning to the end of the study time period. Older patients with a higher general level of morbidity use more health care resources, particularly expensive acute care services.

Aim 4: To assess the relationship between patient characteristics and the utilization of physician, acute care and total health care costs.

Based on the multivariate analysis, the following patient characteristics were associated with being in the high or low physician cost[17] category (see also table 4-54 above):

Table 4-55: Patient Characteristics Associated with High or Low Use of Physician Costs

Patient Characteristic	High Cost Category	Low Cost Category
Adherence[18]	High	Low
Gender		
Age		60-69 years old
Socio-economic status	Low (Quintiles 1&2)	
General morbidity	High or very high	Low
Disease-specific severity	2 or more major complications	No or 1+ minor complications
Patient residence	Delta	Agassiz - Harrison Burnaby Langley Chilliwack

[17] Physician cost categories are based on average annual utilization during the entire five year study period. This binary variable was based on 20% of patients with the highest utilization allocated to the high cost category while the remaining 80% where allocated to the low cost category. Mean costs in the low group were $350 per year compared to $1,053 in the high group. Of the $49.6 million in physician costs used by the study cohort over the five year period, $21.3 million (43%) was used by the 20% of patients allocated to the high utilization category.

[18] In this section, low and high adherence is based on adherence as a categorical variable including three levels (low, medium and high). Individuals in the low, medium and high adherence categories received, on average, 31%, 52% and 73% of recommended clinical procedures, respectively.

Based on the multivariate analysis, the following patient characteristics were associated with being in the high or low acute care cost[19] category (see also table 4-54 above):

Table 4-56: Patient Characteristics Associated with High or Low Use of Acute Care Costs

Patient Characteristic	High Cost Category	Low Cost Category
Adherence	Low	High
Gender	Males	Females
Age	Older	Younger
Socio-economic status		
General morbidity	High or very high	Very low or low
Disease-specific severity	1 or more major complications	No complications
Patient residence	Mission Coquitlam Maple Ridge New Westminster Langley Abbotsford Chilliwack Hope	

Several observations are noteworthy in comparing the summary results for physician and acute care costs. First, patients with high adherence were more likely to be in the high physician cost category but less likely to be in the high acute care cost category. Conversely, patients with

[19] Acute care cost categories are based on average annual utilization during the entire five year study period. This binary variable was based on 20% of patients with the highest utilization allocated to the high cost category while the remaining 80% where allocated to the low cost category. Mean costs in the low group were $299 per year compared to $5,169 in the high group. Of the $128.6 million in acute care costs used by the study cohort over the five year period, $104.4 million (81%) was used by the 20% of patients allocated to the high utilization category.

low adherence were less likely to be in the high physician cost category but more likely to be in the high acute care cost category.

Second, patients with a low socio-economic status were more likely to be in the high physician cost category. Based on the univariate analysis they were also more likely to be in the high acute care cost category, but this significant effect disappeared after adjusting for other patient characteristics.

Third, there appeared to be an association between being in the high physician cost category and the lower utilization of acute care services. For example, only patients living in the LHA of Delta were more likely to be in the high physician cost category than patients in the LHA of Surrey. In contrast, patients in eight of the twelve LHAs were more likely to be in the high acute care cost category than patients in the LHA of Surrey. Furthermore, patients in the LHA of Delta, with their relatively high use of physician services, lived in only one of four LHAs that were equivalent to the LHA of Surrey in their use of acute care costs.

Based on the multivariate analysis, the following patient characteristics were associated with being in the high or low total cost[20] category (see also table 4-54 above):

Table 4-57: Patient Characteristics Associated with High or Low Use of Total Costs

Patient Characteristic	High Cost Category	Low Cost Category
Adherence		Low
Gender	Males	Females
Age	Older	Younger
Socio-economic status		
General morbidity	High or very high	Low
Disease-specific severity	1 or more major complications	No complications
Patient residence	Maple Ridge New Westminster Langley Abbotsford Hope	

When physician and acute care costs were combined into total costs, the results were similar to the analysis for acute care costs only, largely due to the dominance of these costs in the total. That is, of the total $178.2 million dollars of health care resources used by patients in this study over the five year period, $128.6 million (72%) was in acute care services.

There is, however, one very important difference. Combining physician and acute care costs into total costs essentially masked the significant and opposite relationship between

[20] Total costs include both physician and acute care costs. Total cost categories are based on average annual utilization during the entire five year study period. This binary variable was based on 20% of patients with the highest utilization allocated to the high cost category while the remaining 80% where allocated to the low cost category. Mean costs in the low group were $690 per year

adherence and the use of these services. In fact, the multivariate analysis of total costs suggested that patients with low adherence were less likely to be in the high total cost category than are patients with high adherence. As noted earlier, this result was just marginally significant (p=0.041). Nevertheless, it was not expected given the analysis between adherence and physician and acute care costs.

Aim 5: **To determine whether adults with better adherence utilize varying levels of different types of health care.**

The most important result of this study was the observed relationship between long-term adherence to recommended clinical procedures and the use of health care resources. Patients with high long-term adherence (receiving an average of 73% of recommended clinical procedures) were 59% *more* likely to use a high level of physician resources but 22% *less* likely to use a high level of acute care resources. On the other hand, patients with low long-term adherence (receiving on average of 31% of recommended clinical procedures) were 28% *less* likely to use a high level of physician resources but 17% *more* likely to use a high level of acute care resources.

The key difference in costs associated with being in the high or low adherence groups occurred in older adults (i.e., aged 60-79) in the high or very high morbidity categories. Average annual costs in the low adherence category were $2,696 ($2,161 in acute care costs and $535 in physician costs) compared to $2,159 ($1,495 in acute care costs and $664 in physician costs) in the high adherence group. When comparing the low and high adherence groups, average per capita annual acute care costs were 86% higher ($1,820 vs. $977) in the high morbidity group and 76% higher ($4,338 vs. $2,469) in the very high morbidity group for those in the low adherence category. Of the total study population, 7,842 individuals (37% of 20,288) were older

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compared to $6,063 in the high group. Of the $178.2 million in total costs used by the study cohort over the five year period, $122.4 million (69%) was used by the 20% of patients allocated to the high utilization category.

adults with high or very high morbidity categories. Individuals in the low adherence groups were both more likely to be hospitalized and, when they were hospitalized, tended to stay in hospital for longer periods of time.

CHAPTER V: DISCUSSION

This concluding chapter begins with a summary of the key strengths of this study followed by a discussion of several limitations including the generalizability of the findings. The next section presents several important issues that require further research. Finally, the major findings of the study and potential policy implications are discussed.

5.1 Study Strengths

5.1.1 Administrative Data Set

This research analyzed patient data from the BC Linked Health Data set. There are some recognized advantages in using large administrative data sets for research purposes (Roos and Nichol, 1999; Reid et al., 2003; Roos et al., 2004; Roos et al., 2005). Thus, one clear strength of the study was the access to person-specific utilization histories over time that were population based, thus allowing for a population based perspective. This prevented any selection bias. Secondly, large data sets are inexpensive compared to a similar study using primary data. Thirdly, they are unobtrusive, protecting both the individual's privacy and the confidentiality of the data. Fourthly, large data sets are relatively complete. They often include not only utilization data and standard demographic data (e.g. age, gender, etc.) but also such demographic data as location of residence, socio-economic status, marital status, family size, etc. Finally, large data sets are not subject to the recall bias associated with self-report data, or selection bias associated with clinical samples.

The rich detail of the BC Linked Health Data set was a strength. For instance, the data allowed for the capture of age, gender and location of residence. More importantly, the comprehensiveness of the data allowed for the development of novel measures. It was possible

to create an ecologic measure of socio-economic status, a general measure of co-morbidity, and a disease-specific severity index. In addition, the utilization histories in the data set were relatively complete, including an estimated 77% of specialist physician services, 99% of general practitioner services and virtually 100% of acute care services.

A unique strength of this study was the development of an adherence variable based on the repeated receipt (i.e., from three to five times) of recommended clinical procedures over a five year period. The linked health data provided the necessary information to allow for the construction of a measure of long-term adherence. To our knowledge this is the first study to construct a long-term measure of adherence to recommended clinical procedures for patients with type 2 diabetes. Other studies have assessed adherence using a cross-sectional approach by assessing the proportion of individuals who received a specific test or procedure during a recommended time-frame.

There are also concerns about using a linked health data set, the most important of which is associated with the quality of the data. A considerable amount of research attention has been paid to the quality of the data in large administrative data sets. The focus of this research is usually on reliability, or the extent to which agreement exists between two or more data sets (Roos et al., 2005).

Two major approaches used to evaluate data quality are record linkage and re-abstraction. "Record linkage joins two or more separate sources of information to specific individuals present on both files. When both files are supposed to contain the same individuals, the overall match gives an indication of completeness. For matched individuals, the degree of agreement between items on both records provides a degree of reliability" (Roos et al., 2005, page 155). Re-

abstraction focuses on how reliably information moves from a high quality data set (e.g. hospital charts) into computerized form (Roos et al., 2005).

Roos and colleagues (2005) summarize the results of 49 original studies evaluating the reliability of four important Canadian data sets: registries, hospital discharge abstracts, physician visits and prescription drugs. The reliability of the first three of these data sets is of particular relevance to the current study.

In general, Roos et al. (2005) found that agreement (using record linkage) between registries ranged from 91% to 99.8%. Agreement in hospital discharge abstracts (based on re-abstraction) varied between 58% and 100%. As noted in section 3.4.3, this variability is highly dependent on the data field. A review of the Canadian Institute of Health Information's 1999/00 Discharge Abstract Database Data indicated a discrepancy rate between the original and the re-abstracted information of 13.4% with respect to the *most responsible diagnosis* field, 10.0% for the *principal procedure* field, 9.0% for the *postal code* field, 6.5% for the *entry code* field, and so on (Richards et al., 2001). Previous studies have also indicated that the reliability of the main or primary diagnosis and procedure on hospital discharge abstracts is usually above 90% (Roos et al., 1982; Roos et al., 1996). The most common reasons for these discrepancies include the original coder missing information that is included in the medical chart and differences in the interpretation of the documentation (Richards et al., 2001).

Researchers have found that variability ranges, depending on the item. One analysis showed that demographic items are quite accurate with an approximate concordance of 95% between the hospital record and the computerized data base (Hawker et al., 1997; Rawson et al., 1997). Co-morbidities and complications, however, tended to show less agreement with a particularly high level of false negative rates because the complex information available in the

hospital records was not consistently and reliably being captured on the computer database (Malenka et al., 1994; Hawker et al., 1997; Humphries et al., 2000). Thus administrative data sets tend to underestimate the level of co-morbidities and complications. Quan and colleagues (2002) assessed the level of agreement between hospital charts and administrative data for a random group of patients on the 17 co-morbidity variables used in constructing the Charlson index in Alberta. They found that when compared to chart data, administrative data had a lower prevalence in 10 co-morbidities, a higher prevalence in 3 and a similar prevalence in 4. The kappa values ranged from a high of 0.87 to a low of 0.34. Overall, agreement was nearly perfect for one variable, substantial for six, moderate for nine and only fair for one. Similar positive results were found by Tu et al. (2002) in using administrative data to develop an acute myocardial mortality prediction rule in Ontario. Outside of fee-for-service arrangements, the completeness of physician visit records may be a problem (Roos et al., 2005). Relatively little information is available on the completeness and quality of prescription drug databases.

Evidence on the completeness of the BC linked Health Data set, which is the primary data source for this study, has been provided in a number of published studies. Anderson and Kerluke (1996) found they were able to link 94.8% of B.C. Pharmacare Plan A data to individuals in a central population registry based on the patient's date of birth. Hertzman et al. (1997) studied 26,675 sawmill workers from throughout the province who had worked in a sawmill for at least one year between 1950 and 1985. They used probabilistic record linkage (i.e., based on name, birth date, and social insurance number) between the Canadian Mortality Data Base and the British Columbia Cancer Registry. They found that the vital status of the workers was not verifiable for only 14% of the cohort of 26,675. Chamberlayne et al. (1998) assessed the percentage of program file records that were successfully linked to a coordinating

file in the BC Linked Health Data set. A total of 97.0% of hospital separation records, 99.8% of MSP payment records, 97.1% of death records, 96.6% of birth records, 96.0% of long term care records and 98.5% of prescription records for the elderly were successfully linked. Rankin et al. (1999) linked data in the British Columbia Cardiac Registry to the British Columbia Patient Hospitalization Data Base with the use of a unique identifier. They validated the linked data for their study with a chart review of 817 patients at a single hospital (kappa, 0.52 to 0.83).

Roos et al. (2005) concluded that Canadian registries, hospital discharge abstracts and physician files are generally of satisfactory quality, though a significant amount of work remains to be done. They also noted that data quality does not vary systematically between provinces.

5.1.2 Inclusion Criteria

Our research study also improved upon earlier studies on adherence in adults with type 2 diabetes by setting a more stringent standard for inclusion. The majority of other studies assessing adherence to recommended clinical procedures have generally used a population of adults with type 2 diabetes without excluding, in particular, those with newly diagnosed diabetes, those who died, those with other severe competing illnesses and those who were transient. In excluding these sub-populations we removed groups in whom adherence to the recommended clinical procedures could reasonably be expected to be sub-optimal.

Using the standard case finding algorithm of at least two physician visits or one hospital discharge during a two year period coded as having diabetes (i.e., ICD9-250 code, see section 3.5.1 Ascertaining Diabetic Cases for more details), an initial 44,033 individuals with diabetes were found living within the geographic boundaries of the Fraser Health Authority. During the first round of eliminations, we removed any individuals with newly diagnosed diabetes, gestational diabetes, and juvenile diabetes. Incident cases were excluded as adherence patterns

would not be available during the entire five year study period. In addition, adherence patterns in newly diagnosed patients would require some time to establish.

Patients who died (N=3,268) during the five year study period were excluded as their resource use during the final months of life could be expected to be unusually high. In addition, adherence to recommended clinical procedures is not likely a priority during the last stages of an individual's life. Information on patient deaths after March 31, 2001 was not included in the study database. Therefore, patients who died shortly after the end of the study period (March 31, 2001) could still be included in the final study sample, potentially contaminating resource use in the final year with patients who may have died shortly after the end of the study period. This issue is addressed to some degree by the exclusion of patients who had been diagnosed with high impact cancers (N=330), end-stage renal disease (N=282) and AIDS (N=3). In addition, elderly patients over the age of 80 were excluded from the final sample. A key reason for the exclusion of these sub-groups, in addition to high patterns of resource use potentially unrelated to their diabetes, is that issues of adherence may have been usurped by a focus on other existing conditions.

The ability to distinguish between type 1 and type 2 diabetes was problematic, but it is doubtful that this had much of an impact on the outcomes of the research. The administrative database used for this study was not designed to distinguish between patients with type 1 diabetes versus patients with type 2 diabetes. We used an age criterion of 30 years to identify patients with type 1 diabetes (see section 3.5.10 Identification of Specific Sub-Groups). In excluding patients under the age of 30 from the final sample, it is highly likely that a number of patients with type 2 diabetes were caught in this exclusionary net. Furthermore, there are likely a small number of patients with type 1 diabetes remaining in the final sample. The extent of this

cannot be verified using the administrative data, although the proportion of type 1 diabetes in the overall population of individuals with diabetes is estimated at less than 10% versus approximately 90% for type 2 diabetes.

5.2 Study Limitations

There are a number of potential limitations of this study which may have an impact on the validity of conclusions reached and the generalizability of the findings.

5.2.1 Potential Utilization Bias

In using ACGs to assign individuals to morbidity categories, there is the possibility of systematic bias in the measurement of case mix due to differences in physician coding and depth of diagnostic coding. As noted by Reid et al. (2001), "as patients make a greater number of physician visits, they may acquire a greater variety of diagnostic codes. This may drive ACG assignment, but it is difficult to separate cause from effect. Similarly, the lack of coded secondary diagnosis and the use of less specific 3-digit ICD-9 codes may bias in favour of lower acuity ACG assignment" (p.95).

In this study, individuals in the high and very high morbidity categories were 54.2% and 98.4%, respectively, more likely to be in the high adherence group compared to the medium morbidity category (see table 4-54). No significant differences were observed between the very low or low morbidity and the medium morbidity categories. It is possible that this observed relationship is at least partly due to the potential relationship between utilization of the measures tracked in this study and ACG assignment.

The adherence measures used in this study relate largely to lab testing and monitoring rather than diagnostic tests. Nevertheless, if a person has more lab tests, there may be an increase

in diagnosis (e.g. hypercholesterolemia discovered and coded after cholesterol testing) or the specificity of the recorded diagnosis (e.g. change from signs and symptoms to a very specific diagnosis code). Thus more lab tests (i.e. higher adherence) could lead to a greater variety of diagnostic codes potentially influencing ACG assignment. The fact that the adherence measures used in this study tend not to be diagnostic tests mitigates this potential bias to some degree. Nevertheless, if individuals receive one lab test, they are more likely to receive other lab tests which may result in additional diagnoses that may influence ACG assignment.

5.2.2 Missing Drug Cost Variable

In this study we tracked two major sources of health care costs, namely, acute care and physician services. Unfortunately, information on drug costs, a third major source of health care costs, was not available in the BC Linked Health Data set for the entire study population at the time of this research.

Simpson et al. (2003) estimated the health care expenditures for people with diagnosed diabetes in Saskatchewan, including drug costs. They found that of the average annual costs per capita of $3,524, $836 (23.8%) was for prescription drugs. Rubin et al. (1998) suggest a somewhat lower proportion (16%) of total health care costs. Based on these studies, prescription drug costs likely account for approximately 20% of the overall health care costs.

Several studies have assessed the change in prescription drug use associated with improving the planned management of people with diabetes. Villagra et al. (2004) noted an increase in drug costs after the implementation of a diabetes disease management program. They indicated that this was not surprising, “since the program actively promoted use of appropriate drugs and adherence to pharmacologic regimens.” Rubin et al. (1998) found a similar increase in drug costs but further analysis (i.e. adjusting for inflation and cost increases in the control group)

indicated that these costs increased by just 2.1% after the implementation of a diabetes disease management program.

In the study by Simpson et al. (2003), prescription drug costs are a higher proportion of total costs (23.8%) than are physician costs (16.6%). It is possible that an increase in prescription drug costs associated with improved adherence with recommended clinical procedures, together with the observed increases in physician costs, could erode the savings seen in acute care costs. This is clearly an area that requires further research.

5.2.3 Issues of External Validity

External validity is concerned with the extent to which one can generalize the results of the study to broader populations and settings. This study is based on patients with diagnosed diabetes living within the geographic boundaries of the Fraser Health Authority for the entire five year time period between April 1, 1996 and March 31, 2001.

Table 5-1 provides a summary comparison of selected population and health care utilization aspects between residents of the five British Columbia health authorities. This summary is based on research presented in three health atlases produced by the UBC Centre for Health Services and Policy Research (McGrail and Schaub, 2002; McGrail et al., 2004; Watson et al., 2004).

The results summarized in table 5-1 suggested some important differences between residents living within the geographic boundaries of the Fraser Health Authority and residents of other health authorities. The Fraser Health area has seen a substantially more rapid population growth between 1991 and 2001 than any other region. In addition, the population tended to be younger, healthier and had relatively poor access to family practitioners (i.e., as measured by GPs per 10,000 population). Their use of acute care services (i.e., as measured by days per

10,000 population) was also the second lowest in the province. This comparison suggested that the results of the current study may not be directly applicable to others regions in British Columbia.

Table 5-1: Patient Characteristics Of BC Health Authority Residents

	Fraser Health	Vancouver Coastal Health	Vancouver Island Health	Interior Health	Northern Health
Pop. Growth (1991 to 2001)	32.4%	20.7%	14.8%	18.6%	4.6%
% of Pop. 65+ (2001)	11.6%	12.5%	16.6%	16.3%	7.6%
PMR	2.67	2.71	2.88	2.91	3.41
# of FTE FP per 10,000 Pop. (Age/sex adjusted)	7.3	9.7	9.3	8.8	9.4
FP $ per Capita (Age adjusted)	$159	$157	$169	$166	$196
Continuity of Physician Care[21]	0.68	0.72	0.68	0.67	0.67
Hospital Separations per 1,000 Pop. (Age/sex adjusted)	148	126	160	172	189
Acute Care Days per 1,000 Pop. (Age/sex adjusted)	503	496	596	602	734

Notes:
FTE = Full-time Equivalent
FP = Family Practitioner
PMR = Premature Mortality Rate

Because of the number of exclusions that were made to arrive at the final study population, the results in this study may have only limited applicability to the general population of adults with diagnosed type 2 diabetes. The study population consisted of the subset of

patients in which long-term adherence to recommended clinical procedures could reasonably be expected.

5.3 Issues for Further Research

5.3.1 Development of Adherence Measures

The appropriate control of blood glucose, blood pressure and cholesterol levels is vital to the management of diabetes and the avoidance or delay of both acute and long-term complications associated with the disease. In addition, assessing for the early appearance of complications such as retinopathy, nephropathy, neuropathy, cardiovascular disease, etc. is an important component of overall care. In this study we developed a measure of long-term adherence based on the receipt of the following services:

- Two or more HbA1c tests during each fiscal year
- At least four blood pressure measurements each fiscal year
- At least one lipid test every three years
- At least one eye exam during each fiscal year
- At least one microalbumin test during each fiscal year

These services were chosen for the following reasons: 1) clinical importance; 2) ability to track the procedures in the B.C. Linked Health Data set; and 3) recommended as key process variables by the B.C. Chronic Disease Management (BCCDM) program, the Canadian and American Diabetes Associations (i.e., in their clinical practice guidelines), the Veteran's Health

[21] Continuity of care "relates to the receipt of services by a single physician over time. The specific measure of continuity used is the Usual Provider of Care. All payments were aggregated to the patient level and specialty services were attributed back to the referring practitioner. The general practitioner with whom a patient had the most contacts was deemed the 'usual provider'. The Usual Provider of Care measure was constructed as a simple proportion of number of contacts with the usual provider divided by total number of physician contacts". (McGrail et al., 2004, p.102).

Administration in the United States and the Organisation for Economic Co-operation and Development (OECD).

As noted in section 2.4.2 Assessing Adherence to Recommended Clinical Procedures, researchers do not consistently use a standard frequency for assessing adherence to HbA1c testing. The frequency can range from at least once per year to three times every two years to twice per year. On average, however, the assessment of adherence is based on the receipt of at least one HbA1c test per year. The BCCDM has set a standard of a minimum of two HbA1c tests per year. This concurs with recommendations by the American Diabetes Association (2005). Specifically, the ADA recommends at least two HbA1c tests per year in patients who are meeting glycaemic treatment goals and four times per year in those who are not. By using the frequency of two or more tests per year, our measure of adherence to this procedure is likely more stringent than that used in the majority of research studies.

The 2003 Canadian Clinical Practice Guidelines indicates that blood pressure should be measured at least four times per year (i.e., at every visit to the family physician). Measuring and controlling blood pressure is clinically very important in the appropriate management of people with diabetes. Nevertheless, determining whether or not an individual received a blood pressure measurement is not possible from information contained within the BC Linked Health Data set. As a proxy for this measure, we made the reasonable assumption that a blood pressure reading would take place at every GP visit. Thus, if a patient made at least four visits to a GP in a fiscal year (i.e., data available in the data set) we assumed that they had received four blood pressure measurements.

The 2003 Canadian Guidelines recommended a lipid profile every 1-3 years noting that "a fasting lipid profile (TC, HDL-C, TG and calculated LDL-C) should be conducted at the time

of diagnosis of diabetes and then every 1 to 3 years as clinically indicated….More frequent testing should be done if treatment for dyslipidemia is initiated" (p. S60). The OECD, on the other hand, recommended tracking annual cholesterol testing (Greenfeld et al., 2004). Finally, the BCCDM recommended at least one lipid test every three years rather than an annual test. By following the recommendations of the BCCDM, our measure of adherence (one test every three years) to this procedure was likely less stringent than that used in the majority of research studies (one test every year).

A retinal eye exam is recommended at least once every two years, more frequently if the patient has retinopathy. The 2003 Canadian Guidelines noted that "in people with type 2 diabetes, screening and evaluation for retinopathy by an experienced professional should be performed at the time of diagnosis. The interval for follow-up assessments should be tailored to the severity of the retinopathy. In those with no or minimal retinopathy, the recommended interval is 1 to 2 years" (p. S77).

No specific fee code existed in MSP for a retinal eye exam. Instead we used the broader approach recommended by the BCCDM in tracking the following MSP fee items:

- 2010 (consultation – ophthalmology)
- 2015 (eye examination)
- 2039 (fundus photography)
- 2040 (retinoscopy under general anesthetic)
- 2898 (re-examination or minor exam)
- 2899 (full optometric diagnostic).

It is possible that the broader approach used in this study to track this recommended procedure may have overestimated the proportion of adults with diagnosed type 2 diabetes who received a

retinal eye exam. A similarly broad approach, however, was also used by other researchers (Arday et al., 2002).

The 2003 Canadian Guidelines recommended the measurement of serum creatinine levels via a microalbumin test at diagnosis and at least annually thereafter. After a diagnosis of nephropathy in patients with type 2 diabetes, these guidelines noted that the preferred treatment is an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) if the creatinine clearance is >60 mL/min or an ARB if the creatinine clearance is ≤60 ml/min. Furthermore, the guidelines suggested that serum creatinine and potassium levels be checked "within 2 weeks of initiation of therapy and periodically thereafter" (p. S69). The American Diabetes Association (2005) noted that "the role of annual microalbumin assessment is less clear after diagnosis of microalbuminuria and institution of ACE inhibitor or ARB therapy and blood pressure control. Most experts, however, recommend continued surveillance to assess both response to therapy and progression of disease." The controversy associated with whether or not microalbumin assessment should take place after initiation of treatment for microalbuminuria, however, suggests that 100% adherence to this recommended clinical procedure may not be reasonable.

Two general approaches have been used in research assessing adherence to recommended clinical procedures. The first is to provide a detailed assessment of adherence to each recommended clinical procedure (e.g. Saddine et al., 2002) while the second is to combine a series of recommended clinical procedures into a composite score (e.g. McGlynn et al., 2003). In this study we used each of these approaches.

In developing a composite score we combined the five measures into a single measure of long-term adherence by assigning each measure an equal weight. This general approach, rather

than attempting to weight different measures, has been used by the majority of researchers in this area. McGlynn and colleagues (McGlynn et al., 2003; Asch et al., 2004; Asch et al., 2006), for example, used 439 indicators to assess the quality of care provided for 30 different conditions. Each of the indicators received an equal weight, thus allowing the researchers to identify the proportion of recommended procedures received overall as well as for each specific condition.

By including four or more annual visits to a general practitioner as a proxy for blood pressure measurement, it is possible that we double-counted other visit based procedures. That is, patients who saw their physician regularly were also more likely to receive the other procedures tracked in this study. The analysis presented in section 4.3.1 Adherence as a Continuous Variable suggests simply seeing a physician more often does not necessarily lead to receiving appropriate clinical procedures. For example, only 50% of individuals who saw their GP four or more times per year also received two or more HbA1c tests that year. Thus simply increasing the number of visits to a GP or increasing the proportion of patients who see a GP at least four times per year does not appear to assure that the recommended clinical procedures will be received in a timely fashion. Visit-based approaches to improving adherence do not seem to work. This is an issue we will return to in section 5.4 Policy Implications below.

5.3.2 Provider or System Variables

In this study, patients living in the LHAs of South Surrey / White Rock, Burnaby and Langley were more likely to be in the high adherence group while those living in the LHAs of Mission, Maple Ridge and Abbotsford were more likely to be in the low adherence group after adjusting for age, gender, socio-economic status, general morbidity and diabetes disease-specific severity. The reason for the observed association between LHA and adherence was not immediately clear, but may be related to provider or system variables not captured in the study.

Similar variability between adherence and geography was observed by Jencks et al. (2000). These researchers found that adherence varied significantly by US state for annual HbA1c testing, biennial eye exams and biennial lipid profiles. The median rate for HbA1c testing was 71% with a range from 52 to 85%. Similarly, it was 69% for eye exams, with a range from 56 to 80%, and 57% lipid profiles, with a range from 39 to 73%. The authors noted that they "do not yet understand the reasons for these differences or whether aspects of the systems in high-performing states can be easily replicated in low-performing states" (Jencks et al., 2000).

In a follow-up study, Arday et al. (2002) adjusted for patient characteristics such as age, gender, race and socio-economic status. These adjustments reduced the variance between US states in HbA1c tests, eye examinations and lipid profiles by 30, 23 and 27%. But even after adjusting for these patient characteristics, the majority of the variation among states remained unexplained. The authors suggested a number of other possible reasons for the remaining variability, including differences in health care systems, clinical practice patterns, characteristics of state residents not measured in the study such as lack of transportation, other access barriers and cultural factors. In addition they raise the possibility of differential access to physicians and physician reimbursement policies. Arday and coauthors note that further research is required to explore the impact of these potential factors on the observed variability in adherence among US states.

Other studies have assessed variability in adherence to recommended clinical procedures based on the gender of the physician (Kim et al., 2005), whether the physician is a generalist or a specialist (Greenfield et al., 2002), whether the care takes place in a general practice or diabetes clinic setting (De Berardis et al., 2004) and other components of physician's practice (Keating et

al., 2004). In general these studies have found variability in adherence within the range of 5% to 10% based on physician characteristics.

One possibility explaining the variability in adherence by geographic location is differences in the continuity of physician care between LHAs. For example, based on data from 2000/01, the LHAs of Mission and Maple Ridge have the lowest continuity of care score in the Fraser Health Authority (McGrail et al., 2004). These are also two of the three LHAs identified in our analysis in which patients are more likely to be in the low adherence group.

Having a regular primary care provider with whom a patient concentrates his or her care has been associated with improved adherence to prescribed screening, treatment and immunization protocols (Ettlinger and Freeman, 1981; Charney et al., 1967; Safran et al., 1998; Kelly and Shank, 1992; Christakis et al., 2000; Gordis, 1973). In addition, such continuity in care has been credited with positive outcomes such as:

- Fewer acute care hospitalizations (Gill and Mainous, 1998; Harrison, 1998; Smeenk et al., 2000; Bauer et al., 1997; Reid et al., 2003).
- Lower use of emergency rooms (Gill et al., 2000; Christakis et al., 1999; Wasson et al., 1984).
- A general reduction in healthcare costs as continuity of care improves (Raddish et al., 1999; Weiss et al., 1996).
- Better recognition of unidentified health problems (Becker et al., 1974; Gulbradsen et al.., 1997).
- Improved patient satisfaction (Hjortdahl and Laerum, 1992; Weyrauch, 1996).

This research suggests that physician variables may influence both adherence to recommended clinical procedures and the use of several of the key outcome variables followed

in this study. Indeed, the observed association between patient residence (i.e., the local health area variable) and adherence and resource use variables may actually be a proxy for physician variables. It would be important to assess this relationship in future research.

One issue that should be assessed is the influence of continuity of care on adherence. General practitioners value the ability of being able to provide accessible, comprehensive and continuous care (Braunack-Mayer, 2005; Stokes et al., 2005) and, as noted above, previous research has suggested that continuity of care has a measurable influence on adherence and health care resource use.

In studying the concept of *continuity of care*, researchers have identified three types of continuity (Reid et al., 2002; Haggerty et al., 2003). *Informational continuity* means that information on prior events is used to give care that is appropriate to the patient's current circumstances. *Relational continuity* recognizes the importance of the patient as a person; an ongoing relationship between patients and providers is the under girding that connects care over time and bridges discontinuous events. *Management continuity* ensures that care received from different providers is connected in a coherent way. Management continuity is usually focused on specific, often chronic, health problems. Reid et al. (2003) assumed that relational continuity exists when "patients concentrate their care with particular physicians or see the same physician sequentially" (p. 3).

Reid also stated that "continuity is the result of a combination of adequate access to care for patients, good interpersonal skills, good information flow and uptake between providers and organizations, and good care coordination between providers to maintain consistency. For patients, it is the experience of care as connected and coherent over time. For providers, it is the experience of having sufficient information and knowledge about a patient to best apply their

professional competence and the confidence that their care is recognized and pursued by other providers" (Reid et al., 2002; p. iv).

Reid et al. (2003) investigated ways of measuring continuity in the context of primary care, with a focus on relational continuity. "In general, the measures constructed over a two year data window outperformed those constructed over only one year, both in their concurrence with self report of a regular source of care and in prediction of future hospitalizations. Similarly, the measures constructed with primary care visits with the specialist visits referrals attributed back to the originating physician significantly outperformed those that included primary care visits only. This finding is consistent with the notion that speciality and primary care visits are 'connected' (and thus continuous) through the process of referral." (p. ii-iii).

The potential impact of relational continuity of care, in addition to other potential provider or system variables, on long-term adherence to recommended clinical procedures for patients with diagnosed type 2 diabetes is an important future research question.

5.4 The Study Findings in Perspective

5.4.1 Adherence Rates

Despite carefully removing any group of individuals for whom long-term adherence might not be appropriate, the overall rate of adherence in this study was far from optimal. Just 53% of recommended clinical procedures were received over the five years. This, of course, just reflects whether the appropriate tests were done, not whether they resulted in appropriate management decisions. When the study population was divided into low, medium and high adherence groups, the overall rates of adherence were 31%, 52% and 73%, respectively. Thus 5,136 patients (the low adherence group) in Fraser Health received just 31% of recommended clinical procedures throughout the five year study period. On a more positive note, we did

discover that adherence to the individual measures tracked in this study improved over time but it would take a *long* time to reach optimal adherence given this trend.

The proportion of patients receiving the recommended clinical procedures increased between 1996/97 and 2000/01 as follows:

- From 35% to 52% for two or more HbA1c tests per year
- From 36% to 39% for at least one eye exam per year
- From 13% to 38% for at least one urinary microalbumin test per year
- From 77% to 82% for at least one lipid test every three years
- From 81% to 85% for at least four BP measurements per year

The literature indicated that a substantial proportion of people with diagnosed diabetes were not receiving the recommended clinical procedures. Rubin and co-workers (1998) noted that only 34% of people with diabetes in their study population had at least one HbA1c test per year, only 23% had an annual eye exam, and only 39% received a yearly cholesterol screening. McGlynn et al. (2003) found that only 24% of adults with diabetes had received three or more glycosylated haemoglobin tests over a two-year period, and a bare 14% had an annual eye exam. They noted that 58% had their total serum cholesterol and HDL cholesterol tests documented. Overall, the study by McGlynn and colleagues revealed that people with diabetes received just 45% of the processes recommended for basic care of their chronic condition. The United States Agency for Healthcare Research and Quality published a report (i.e., *National Healthcare Quality Report*, 2003) which noted that only 21% of patients with diabetes reported having the following five major tests done over a two year time period: influenza vaccination, foot exam, retinal eye exam, HbA1c measurement and lipid profile.

In Winnipeg, Manitoba, Katz et al. (2004) found that 54% of patients with diabetes had a cholesterol screening test and 37% had an eye exam during a one year period. In Ontario, Harris et al. (2003) found that 84% of their random sample of patients with diabetes had at least one HbA1c test ordered in the previous year, 28% were tested for microalbuminuria, 15% were examined for diabetes-related foot problems, 88% had their blood pressure measured, and 48% had their lipid profiles documented in their chart.

The British Columbia Chronic Disease Management (BCCDM, 2003) department of the BC Ministry of Health Services accessed administrative data to determine whether patients throughout the province were receiving the series of services recommended in current clinical practice guidelines. In the fiscal year 2002/03, only 39% of people with diagnosed diabetes in the province had two or more HbA1c tests (see section 3.5.1 Ascertaining Diabetic Cases for the BCCDM algorithm used to identify individuals with diagnosed diabetes). A higher number (i.e., 43%) had an eye exam, but only 34% had a microalbumin test. The most encouraging finding was that 78% had at least one lipid test in the three years from 2000/01 to 2002/03 (BCCDM, 2003).

The literature also revealed that while overall results suggest suboptimal adherence, there has been some improvement in adherence over time, at least in certain jurisdictions. Using a retrospective chart review, Stolar et al. (1995) gauged the impact of the ADA's 1988 clinical practice guidelines for patients with type 2 diabetes. They assessed adherence to recommended clinical procedures for the three years before and after the 1988 guidelines were published and found significant improvements in the proportion of patients receiving an eye exam, an HbA1c test, a lipid test and a urinary microalbumin test during the six year period. Jencks et al. (2003) assessed changes in the proportion of Medicare beneficiaries with diabetes who received at least

one HbA1c test per year, at least one eye exam every two years and at least one lipid profile every two years. Between 1998/99 and 2000/01, these proportions increased from 70% to 78%, 69% to 70% and 58% to 74% respectively.

In England, Campbell and colleagues (2005) used medical records data to assess changes in the receipt of recommended care between 1998 and 2003. They found a significant improvement in the quality of care provided to individuals with type 2 diabetes during that time. More specifically, the proportion of individuals who had at least one HbA1c tests during the previous 15 months increased from 87.6% to 92.7%. Similar increases were observed for the measurement of serum creatinine levels (from 79.8% to 89.5%) and serum cholesterol levels (from 74.9% to 97.6%). Increases for eye exams (from 70.8% to 71.8%) and blood pressure (from 92.8% to 94.6%) were more modest.

The move toward better care has been evident in British Columbia. In this province, the proportion of people with diagnosed diabetes who received two or more HbA1c tests per year increased from 31% in 1999/00 to 39% in 2002/03. Similarly, the proportion with at least one microalbumin test per year increased from 22% to 34%. The proportion with at least one lipid tests in three years increased from 61% to 78%. Unfortunately, the proportion of people with at least one eye exam per year decreased from 47% to 43% (BCCDM, 2004).

Thus neither the relatively low adherence nor the subsequent improvement in adherence observed in this study was unusual or unexpected. It is important to note, however, that this suboptimal level of adherence is not isolated to patients with diabetes (McGlynn et al., 2003) nor to specific countries (Schoen et al., 2005).

5.4.2 Patient Characteristics Associated with Low Adherence

Several patient characteristics were associated with the probability of being in the low adherence group. These include being male, younger age, low socio-economic status, having no diabetes-specific complicating conditions and living in certain geographic areas (i.e., Mission, Maple Ridge and Abbotsford).

In the current study, after adjusting for sex, age, socio-economic status, morbidity, disease-specific severity and geographic location, females were 33.6% more likely than males to be in the high adherence category (see table 4-54). Woodward et al. (2006) found that females with diabetes were 13% *less* likely to receive at least one HbA1c test per year. This study adjusted for age, sex, rural residence and utilization of the health care system but not for patient morbidity or socio-economic status. Furthermore, this study provided a one year snapshot of adherence to HbA1c testing. Arday et al. (2002) found that females were 5.2% more likely to receive an annual HbA1c test, 34.2% more likely to receive a biennial eye exam and 9.9% less likely to receive a biennial lipid profile. This study adjusted for age, sex, race, eligibility for both Medicare and Medicaid, ESRD, socio-economic status, number of outpatient visits, comorbidities and illness severity. As with the Woodward et al. study, however, adherence is based on a single measure over the two-year study period. In a broader study of adherence to recommended care received by patients with a variety of chronic conditions, Asch et al. (2006) found that males were just marginally less likely to receive recommended care than females. The relatively strong association between gender and adherence observed in the current study may be due to the fact that we observed long-term, repeated adherence to recommended care rather than an annual or biennial snapshot of adherence.

In the current study, age was an important predictor of adherence. Individuals with diagnosed type 2 diabetes between the ages of 30-39 were 35.4% less likely to be in the high adherence group than those aged 50-59 while those aged 40-49 were 17% less likely to be in the high adherence group. On the other hand, those aged 60-69 were 42.8% more likely and those 70-79 were 24.8% more likely to be in the high adherence group compared to 50-59 years olds (see table 4-54). Both Woodward et al. (2006) and Asch et al. (2006) found a similar relationship between adherence and age, with adherence improving with increasing age but then decreasing somewhat for the oldest age group. Arday et al. (2002) found a small but significant increase in adherence to annual HbA1c testing (1.0%), the receipt of a biennial eye exam (3.8%) and lipid profile (1.2%) for those over the age of 65 compared to those less than 65 years of age.

In the current study, individuals in the lowest socio-economic quintile were 10.1% less likely to be in the high adherence group than those in the middle socio-economic quintile (see table 4-54). Arday et al. (2002) found a small but significant increase in adherence to annual HbA1c testing (1.4%), the receipt of a biennial eye exam (1.5%) and lipid profile (1.7%) for individuals with a higher compared to lower socio-economic status. Asch et al. (2006) noted that individuals with a household income of greater than $50,000 were significantly more likely to receive the recommended care associated with their chronic condition than those with a household income of less than $15,000. The Canadian study by Woodward et al. (2006) did not measure socio-economic status.

In the current study, individuals with no disease-specific complicating conditions were 37.8% less likely to be in the high adherence group than those with one or more complicating conditions. Arday et al. (2002) found a significant increase in adherence to annual HbA1c testing (41.1%), the receipt of a biennial eye exam (99.8%) and lipid profile (1.0%) for

individuals with at least one diabetes-specific complication compared to those with no diabetes-specific complications.

The geographic location of the patient's residence also proved to be an important variable associated with whether or not an individual was in the high adherence group. Individuals living in the LHAs of Mission (23.6%), Maple Ridge (21.8%) and Abbotsford (18.1%) were all less likely to be in the high adherence group compared to those living in the LHA of Surrey, even after adjusting for covariates. On the other hand, individuals living in the LHAs of South Surrey/White Rock (26.8%), Langley (37.3%) and Burnaby (38.3%) were all more likely to be in the high adherence group compared to those living in the LHA of Surrey (see table 4-54). This relationship between geographic location and adherence to recommended clinical procedures has been observed previously in the United States (Jencks et al., 2000; Arday et al., 2002). As noted in section 5.3.2 Provider or System Variables above, the observed association between geographic location and long-term adherence may be explained by provider or system variables not captured in the current study.

We identified several patient characteristics associated with the probability of being in the low adherence group. It is important to note that the literature also identifies a number of patient characteristics associated with non-adherence not included in the current research. These characteristics include depression, lack of social support, family conflict and poor communication between the patient and their health care professional (Devine and Pearcy, 1996; DiMatteo et al., 2000; DiMatteo, 2004a; DiMatteo, 2004b, DiMatteo and Haskard, 2006). The relationship between poor adherence and a number of patient characteristics is particularly important given the unequivocal relationship between the tight control of blood glucose and blood pressure levels in patients with diabetes and a reduction in both acute and chronic

complications. To quote the American Diabetes Association: "it is time for all health professionals to treat diabetes aggressively. It is also time for patients to take their diabetes with the utmost seriousness. And it is incumbent upon the health care system to provide the necessary resources for both to be successful. Compromise or acceptance of a disadvantageous and dangerous status quo in people with diabetes should not be tolerated any longer" (Genuth et al., 2003, p. S32). In addition to reducing a patient's longevity and quality of life, the complications associated with poorly managed diabetes result in significant costs to the health care system.

5.4.3 Utilization of Health Care Resources

On average over the five year period from April 1, 1996 to March 31, 2001, each individual in the current study used 1.62 acute care inpatient days per year at an estimated cost of $1,148. In addition, they utilized an average of $124 in surgical day care services per person per year. The average number of physician visits per person per year consisted of 9.74 GP visits at a cost of $302 and 2.88 specialist physician visits at a cost of $189. Average annual costs per person were $1,762 consisting of $491 (28%) in physician costs and $1,272 (72%) in acute care costs.

Between 1996/97 and 2000/01, the annual utilization of all resources increased significantly. Mean acute care costs increased from $1,013 in 1996/97 to $1,605 in 2000/01 (58%). Mean physician costs increased from $436 in 1996/97 to $535 in 2000/01 (23%). Mean total costs increased from $1,449 in 1996/97 to $2,140 in 2000/01 (48%). On a year over year basis, total costs (in constant 2000/01 dollars) per person increased by 13.9% from 1996/97 to 1997/98 and by 3.6%, 9.0% and 14.9%, respectively, in each of the following years.

It should be remembered that this is a cohort study in which the same subjects were followed during the five years of the study period. As such, they would be five years older on

March 31, 2001 than on April 1, 1996. In addition, since incident cases are not included in the study population, the subjects would also have had type 2 diabetes for an additional five years by the end of the study period compared to the beginning of the study period.

During the same time period, adherence to the individual recommended clinical procedures tracked in this study improved. What impact has this trend in improved adherence over time had on physician and hospital costs? It would be important in future research to examine the increasing costs observed over time for the study cohort in the context of the increasing age, disease duration and improved adherence of the patient cohort. That is, how do these three critical variables interact with physician and hospital costs and what is the impact of each in determining overall system costs over time?

How did the overall utilization of health care resources in our study population compare to other studies? The closest research, in both time and geography, which we found to help us answer this question, was the research by Simpson et al. (2003). These researchers estimated the health care expenditures for people with diagnosed diabetes in Saskatchewan in 1996 (N=38,124). Average costs per capita were $3,524 consisting of $1,889 (53.7% of the total) in hospitalization costs, $836 (23.8%) in prescription drug costs, $583 (16.6%) in physician services costs, $115 (3.3%) in dialysis costs and $96 (2.7%) in day surgery costs.

The mean annual acute care costs in the current study over the five year period from 1996/97 to 2000/01 of $1,272 include both hospitalization and day surgery and are thus comparable to $1,985 ($1,889 in hospitalization costs plus $96 in day surgery costs) in the Simpson et al. (2003) study. The mean annual physician costs in the current study of $491 are comparable to $583 in the Simpson et al. (2003) study.

A key difference between the two studies was the selection of the target population. The Simpson et al. (2003) study included all individuals with diagnosed diabetes in Saskatchewan. The current study began with a population of 44,033 (all individuals with diagnosed diabetes living in the geographic boundaries of the Fraser Health Authority). This population of individuals with diagnosed diabetes was then reduced to 20,228 (see section 3.5 Subject Sample). Part of the process of exclusion involved the elimination of the sickest patients from the study population (i.e. those who died, had been diagnosed with high impact cancers, end-stage renal disease and AIDS or were over the age of 80). If the sicker and older patients had not been excluded, the average resource use would likely have been higher in the current study.

5.4.4 The Relationship between Long-Term Adherence and Use of Health Care Resources

The most important result of this study is the observed relationship between long-term adherence to recommended clinical procedures and the use of health care resources. Patients with high long-term adherence (receiving an average of 73% of recommended clinical procedures) are 59% *more* likely to use a high level of physician resources but 22% *less* likely to use a high level of acute care resources. On the other hand, patients with low long-term adherence (receiving on average of 31% of recommended clinical procedures) are 28% *less* likely to use a high level of physician resources but 17% *more* likely to use a high level of acute care resources.

The observed increased physician costs in the high adherence group include the costs of that improved adherence. That is, seeing the physician more often and receiving the recommended clinical procedures on a more routine basis likely result in an increase in physician costs. How much of the observed increase is due to increased adherence and how much is due to other factors is an important question for future research.

The key difference in costs associated with being in the high or low adherence groups occurred in older adults (i.e., aged 60-79) in the high or very high morbidity categories. Average annual costs in the low adherence category were $2,696 ($2,161 in acute care costs and $535 in physician costs) compared to $2,159 ($1,495 in acute care costs and $664 in physician costs) in the high adherence group. When comparing the low and high adherence groups, average per capita annual acute care costs were 86% higher ($1,820 vs. $977) in the high morbidity group and 76% higher ($4,338 vs. $2,469) in the very high morbidity group for those patients in the low adherence category. Of the total study population, 7,842 individuals (37% of 20,288) were older adults with high or very high morbidity categories. Individuals in the low adherence groups were more likely to be hospitalized and, when they were hospitalized, tended to stay in hospital for longer periods of time.

5.5 Policy Implications

There are a number of policy implications associated with the results of this research. After adjusting for age, gender, socioeconomic status, general morbidity, disease-specific severity and patient residence, several patient-level characteristics were associated with a higher likelihood of poor adherence to recommended clinical procedures. Thus patients who were younger males, without disease-specific complications, and/or in the lowest socio-economic group were found in this category. The fact that patients living within the geographic boundaries of the Mission, Maple Ridge and Abbotsford LHAs were also in the low adherence category deserves further research, specifically to determine if the association involved system or physician specific characteristics.

As noted earlier, this finding is particularly important given the unequivocal relationship between the tight control of blood glucose and blood pressure levels in patients with diabetes and a reduction in both acute and chronic complications.

Our research supports the idea that long-term adherence to recommended clinical procedures can result in a reduction in overall health care resources, particularly for specific patient groups. High adherence was more strongly associated with reduced acute care costs as patients became older and developed higher levels of morbidity. While we measured adherence over a five year time period, it is likely that these same patterns of adherence held prior to the study period. We hypothesize that patterns of high adherence sustained over a much longer time for this group of elderly patients ultimately accounted for the positive results observed in our study. In this light, it would be important from a policy perspective to have people with lower adherence move into higher adherence categories as early as possible.

We estimated the potential cost impact if people with diagnosed type 2 diabetes improved in adherence based on the following scenarios:

- If all individuals in the **low** adherence category moved into the **medium** adherence category
- If all individuals in the **low** adherence category moved into the **high** adherence category
- If all individuals in the **medium** adherence category moved into the **high** adherence category
- If all individuals in the **low** adherence category moved into the **medium** adherence category and those in the **medium** category moved into the **high** category
- If all individuals moved into the **high** adherence category

The results of this analysis are summarized in table 5-2 below (see appendix E for details).

Table 5-2: Potential Annual
Acute Care, Physician and Total Costs
Based on Improving Adherence
(in $millions)

Individuals in the low adherence category moved into the medium adherence category

	Current	Expected	Variance	% Variance
Acute	25.72	24.52	(1.20)	-4.7%
Physician	9.92	10.20	0.28	2.8%
Total	**35.65**	**34.72**	**(0.93)**	**-2.6%**

Individuals in the low adherence category moved into the high adherence category

	Current	Expected	Variance	% Variance
Acute	25.72	23.77	(1.96)	-7.6%
Physician	9.92	10.46	0.54	5.4%
Total	**35.65**	**34.23**	**(1.42)**	**-4.0%**

Individuals in the medium adherence category moved into the high adherence category

	Current	Expected	Variance	% Variance
Acute	25.72	23.67	(2.05)	-8.0%
Physician	9.92	10.41	0.49	4.9%
Total	**35.65**	**34.08**	**(1.56)**	**-4.4%**

Individuals in the low adherence category moved into the medium adherence category and those in the medium category moved into the high category

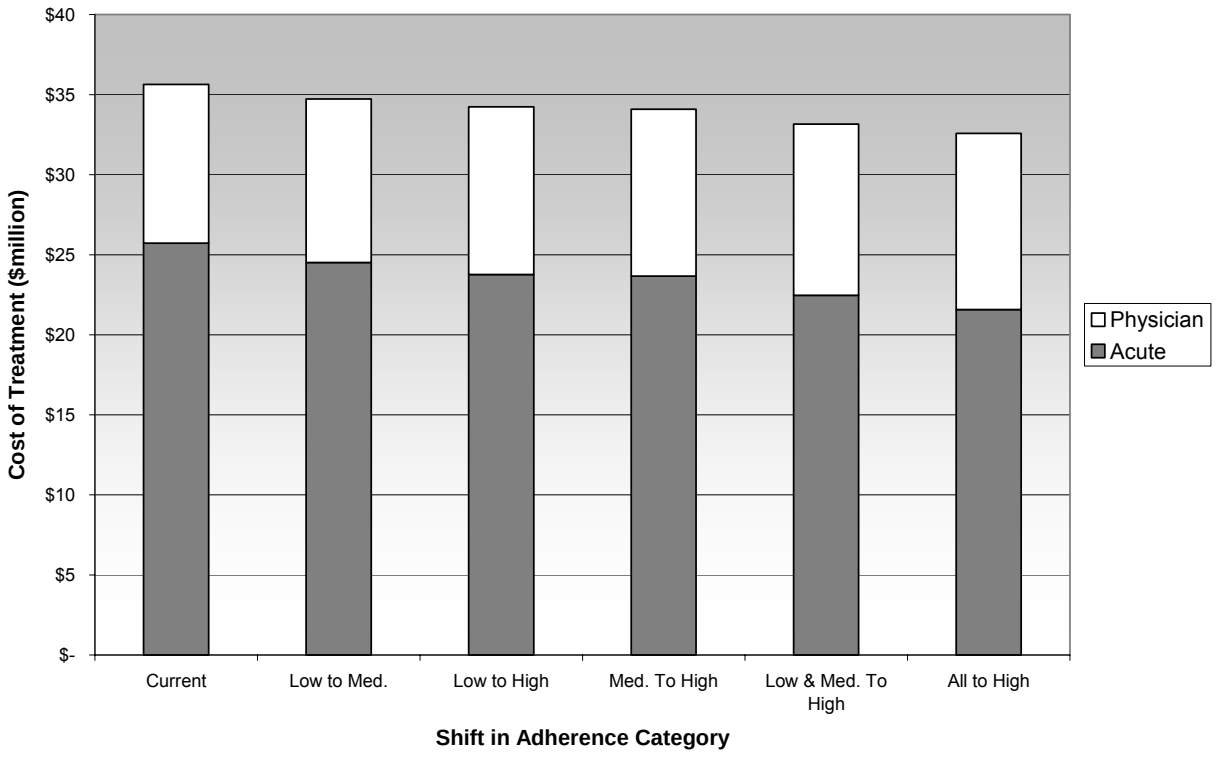
	Current	Expected	Variance	% Variance
Acute	25.72	22.47	(3.26)	-12.7%
Physician	9.92	10.69	0.77	7.7%
Total	**35.65**	**33.16**	**(2.49)**	**-7.0%**

All individuals moved into the high adherence category

	Current	Expected	Variance	% Variance
Acute	25.72	21.58	(4.15)	-16.1%
Physician	9.92	11.01	1.08	10.9%
Total	**35.65**	**32.58**	**(3.06)**	**-8.6%**

The same information is provided in graphical format in figure 5-1 below.

Figure 5-1: Potential Annual Acute Care and Physician Costs
Based on Improving Adherence



Based on the current study sample of 20,288 individuals with diagnosed type 2 diabetes living within the geographic region of the Fraser Health authority, moving the 5,136 individuals currently in the low adherence category (with an average adherence rate of 31%) to the medium adherence category (with an average adherence rate of 52%) would increase annual physician costs by $0.28 million while resulting in an avoidance of $1.20 million in acute care costs.

If, on the other hand, all individuals were moved into the high adherence category (with an average adherence rate of 73%), annual physician costs would increase by $1.08 million while acute care costs would decrease by $4.15 million, resulting in $3.06 million in costs avoided. For every dollar of increased physician costs, acute care costs would be reduced by four dollars.

Could this analysis be extended to the entire population of individuals with diagnosed diabetes in British Columbia? To do so would require the assumption that the observed relationship between adherence and health care utilization for patients with type 2 diabetes living within the geographic boundaries of the Fraser Health authority held for all patients with diagnosed diabetes in the province. Furthermore, the proportion of individuals in the low, medium and high adherence categories would need to be the same throughout the province as that observed in the current study.

To extend the analysis to the entire province, we calculated the per capita change in acute care, physician and total costs associated with the scenarios noted above (see table 5-3).

Table 5-3: Potential Annual per Capita
Change in Acute Care, Physician and Total Costs
Based on Improving Adherence

	Low to Med	Low to High	Med. To High	Low & Med. To High	All to High
Acute	$ (59.24)	(96.39)	(101.26)	(160.51)	(204.37)
Physician	$ 13.63	26.47	24.20	37.83	53.37
Total	**$ (45.62)**	**(69.92)**	**(77.06)**	**(122.68)**	**(151.00)**

In 2003/04, the BC Chronic Disease Management (BCCDM, 2004b) estimated that there were 228,013 individuals living in the province with diagnosed diabetes. We multiplied these per capita costs to the entire population of people with diagnosed diabetes in the province assuming a distribution to adherence category similar to the cohort in the current study. This resulted in a range of annual costs avoided of $10.4 million to $34.4 million. If, for example, individuals in the low adherence category were moved into the medium adherence category, then physician costs would increase by $3.1 million while acute care costs avoided would increase by $13.5 million. If all individuals with diagnosed diabetes were moved into the high adherence category,

then physician costs would increase by $12.2 million while acute care costs avoided would increase by $46.6 million.

While our research focused on the health care costs associated with adherence to recommended clinical procedures, of more importance, at least to the patient, are potential differences in morbidity and quality of life associated with higher adherence. Although we did not assess this relationship in the current study, fewer hospitalizations (especially over a five year time period) suggest a lower level of morbidity, one of the important outcomes related to appropriate care for patients with type 2 diabetes.

How can adherence be improved? Our research indicated that an approach based simply on general practitioner visits is not a likely solution. Patients who visit their GP regularly still do not receive the recommended clinical procedures. For example, in 2001, just 55% of patients who saw there GP four or more times per year also received two or more HbA1c tests. Research that examined solutions applied in other organizations indicated that a systems-based approach is more likely to lead to improved adherence.

A systematic review by Grimshaw et al. (2001) of interventions designed to change provider behaviour noted that multifaceted interventions targeting different barriers to care were likely to be more effective than single interventions. The most successful programs addressed: 1) clinician behaviour; 2) changes to the organization of practice; 3) information system enhancement; 4) and educational or supportive programs aimed at patients (Renders et al., 2001; Rothman and Wagner, 2003). Renders et al. (2004) noted that key aspects of successful CPG implementation in the care of diabetic patients included: 1) organizational interventions that improved regular prompted recall and review of patients; 2) a stress on patient-oriented

interventions; and, 3) the utilization of nurses in patient education and the facilitation of adherence to treatment.

Wagner and colleagues in Seattle have developed a chronic care model which includes: 1) key linkages with community resources; 2) active leadership support; 3) more consistent and collaborative self-management support; 4) system redesign to include non-physician personnel in practice teams; 5) clinical information system enhancements to include reminders and feedback on the care provided; and, 6) attention to co-morbid conditions (Wagner et al., 1996; Wagner et al., 2001; Bodenheimer et al., 2002a, 2002b, 2002c; Heisler and Wagner, 2004).

An important aspect of the chronic care model is the concept of patient self-management. "Patients with chronic conditions make day-to-day decisions about – self-manage – their illnesses. This reality introduces a new chronic disease paradigm: the patient-professional partnership, involving collaborative care and self-management education" (Bodenheimer et al., 2002c). As noted in the background section, Bodenheimer et al. (2002c) provide the following comparison of traditional and collaborative care in chronic illness.

Table 5-4 Comparison of Traditional and Collaborative Care in Chronic Illness		
Issue	**Traditional Care**	**Collaborative Care**
What is the relationship between patient and health professional?	Professionals are the experts who tell patients what to do. Patients are passive.	Shared expertise with active patients. Professionals are experts about the disease and patients are experts about their lives.
Who is the principal caregiver and problem solver? Who is responsible for outcomes?	The professional.	The patient and professional are the principal caregivers; they share responsibility for solving problems and for outcomes.
What is the goal?	Compliance with instructions. Non-compliance is a personal deficit of the patient.	The patient sets goals and the professional helps the patient make informed choices. Lack of goal achievement is a problem to be solved by modifying strategies.
How is behaviour changed?	External motivation.	Internal motivation. Patients gain understanding and confidence to accomplish new behaviours.
How are problems identified?	By the professional, e.g. changing unhealthy behaviours.	By the patient, e.g., pain or inability to function; and by the professional.
How are problems solved?	Professional solve problems for patients.	Professionals teach problem-solving skills and help patients in solving problems.

Early results, in terms of both adherence and outcomes, from the implementation of this chronic care model (CCM) in a variety of settings are very positive (Bodenheimer et al., 2002), though more formal evaluations need to be carried out, including assessment of longer term patient outcomes (Narayan et al., 2004). Tsai et al. (2005) surveyed the available literature to determine whether interventions that incorporate at least one element of the chronic care model result in improved outcomes for individuals with asthma, congestive heart failure, depression and diabetes. They concluded that “interventions with at least 1 CCM element had consistently beneficial effects on clinical outcomes and processes of care across all conditions studied”.

Beginning in 1995, the Department of Veterans Affairs (VA) in the US embarked on a nation-wide effort to reengineer its services with a view towards improving both efficiency and effectiveness of delivery. Kerr et al. (2004) compared the outpatient care received by patients with diabetes in the VA system to that found in commercial managed-care systems. The results showed that patients in the VA system were more likely to receive HbA1c testing, counselling about aspirin use, and eye and foot examinations. They also had better lipid control. A review of 177 Veteran's Affairs clinics in the United States found that programs "associated with better diabetes control simultaneously have teams that actively involve physicians in quality improvement, use electronic health information systems, have authority to respond to staffing and programmatic issues, and engage patients in care." (Jackson et al., 2005, p. 225)

In conclusion, while adherence to recommended clinical procedures for diabetes is generally poor, a number of organizational factors which can improve adherence have been identified in the literature. These include:

- the inclusion of non-physician personnel in practice teams
- information systems designed to provide timely reminders and feedback
- active leadership support
- enhanced patient education and self-management support
- attention to co-morbid conditions
- key linkages with community resources

Reengineering the primary health care system to include these organizational factors should result in improved adherence to recommended clinical procedures for individuals with diagnosed type 2 diabetes leading to an overall reduction in health care system costs while improving the patient's quality of life.

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Appendix A: Allocation of ACGs Into Morbidity Levels

The following ACGs were allocated into each of the five categories:

- Level 1 – Very low co-morbidity
- Level 2 – Low co-morbidity (2 or 3 types of conditions)
- Level 3 – Medium co-morbidity (4 or 5 types of conditions)
- Level 4 – High co-morbidity (6 to 9 types of conditions)
- Level 5 – Very high co-morbidity (10+ types of conditions)

Level 1 – Very low co-morbidity

- 0100 Acute Minor, Age 1
- 0200 Acute Minor, Age 2-5
- 0300 Acute Minor, Age 6+
- 0400 Acute: Major
- 0500 Likely to Recur, without Allergies
- 0600 Likely to Recur, with Allergies
- 0700 Asthma
- 0800 Chronic Medical, Unstable
- 0900 Chronic Medical, Stable
- 1000 Chronic Specialty
- 1100 Eye/Dental
- 1200 Chronic Specialty, Unstable
- 1300 Psychosocial, without Psychosocial: Unstable
- 1400 Psychosocial, with Psychosocial: Unstable, without Psychosocial: Stable
- 1500 Psychosocial, with Psychosocial: Unstable and Psychosocial: Stable
- 1600 Preventive/Administrative

Level 2 – Low co-morbidity (2 or 3 types of conditions)

- 1800 Acute Major and Acute Minor
- 1900 Acute Minor and Likely to Recur, Age 1
- 2000 Acute Minor and Likely to Recur, Age 2-5
- 2100 Acute Minor and Likely to Recur, Age > 5, without Allergy
- 2200 Acute Minor and Likely to Recur, Age > 5, with Allergy
- 2300 Chronic Medical: Stable and Acute Minor
- 2400 Eye/Dental and Acute Minor
- 2500 Psychosocial without Psychosocial: Unstable and Acute Minor
- 2600 Psychosocial with Psychosocial: Unstable, without Psychosocial: Stable and Acute Minor

- 2700 Psychosocial with Psychosocial: Unstable and Psychosocial: Stable and Acute Minor
- 2800 Acute Major and Likely to Recur
- 2900 Acute Major/Acute Minor/Likely to Recur, Age 1
- 3000 Acute Major/Acute Minor/Likely to Recur, Age 2-5
- 3100 Acute Major/Acute Minor/Likely to Recur, Age 6-11
- 3200 Acute Major/Acute Minor/Likely to Recur, Age> 12, without Allergy
- 3300 Acute Major/Acute Minor/Likely to Recur, Age> 12, with Allergy
- 3400 Eye & Dental/Acute Minor/Likely to Recur
- 3500 Psychosocial/Acute Minor/Likely to Recur
- 3800 2-3 Other ADG Combinations, Age < 17
- 3900 2-3 Other ADG Combinations, Males Age 18-34
- 4000 2-3 Other ADG Combinations, Females Age 18-34
- 4100 2-3 Other ADG Combinations, Age > 34

Level 3 – Medium co-morbidity (4 or 5 types of conditions)

- 3600 Chronic Medical: Stable/Acute Major/Likely to Recur/Acute Minor
- 3700 Psychosocial/Acute Minor/Acute Major/Likely to Recur
- 4210 4-5 Other ADG Combinations, Age 1-17, no major ADG
- 4220 4-5 Other ADG Combinations, Age 1-17, 1+ major ADGs
- 4310 4-5 Other ADG Combinations, Age 18-44, no major ADG
- 4320 4-5 Other ADG Combinations, Age 18-44, 1 major ADG
- 4330 4-5 Other ADG Combinations, Age 18-44, 2+ major ADGs
- 4410 4-5 Other ADG Combinations, Age > 45, no major ADG
- 4420 4-5 Other ADG Combinations, Age > 45, 1 major ADG
- 4430 4-5 Other ADG Combinations, Age > 45, 2+ major ADGs

Level 4 – High co-morbidity (6 to 9 types of conditions)

- 4510 6-9 Other ADG Combinations, Age 1-5, no major ADG
- 4520 6-9 Other ADG Combinations, Age 1-5, 1+ major ADGs
- 4610 6-9 Other ADG Combinations, Age 6-17, no major ADG
- 4620 6-9 Other ADG Combinations, Age 6-17, 1+ major ADGs
- 4710 6-9 Other ADG Combinations, Males Age 18-34, no major ADG
- 4720 6-9 Other ADG Combinations, Males Age 18-34, 1 major ADG
- 4730 6-9 Other ADG Combinations, Males Age 18-34, 2+ major ADGs
- 4810 6-9 Other ADG Combinations, Females Age 18-34, no major ADG
- 4820 6-9 Other ADG Combinations, Females Age 18-34, 1 major ADG
- 4830 6-9 Other ADG Combinations, Females Age 18-34, 2+ major ADGs
- 4910 6-9 Other ADG Combinations, Age > 35, 0-1 major ADG
- 4920 6-9 Other ADG Combinations, Age > 35, 2 major ADGs
- 4930 6-9 Other ADG Combinations, Age > 35, 3 major ADGs
- 4940 6-9 Other ADG Combinations, Age > 35, 4+ major ADGs

Level 5 – Very high co-morbidity (10+ types of conditions)

- 5010 10+ Other ADG Combinations, Age 1-17, no major ADG
- 5020 10+ Other ADG Combinations, Age 1-17, 1 major ADG
- 5030 10+ Other ADG Combinations, Age 1-17, 2+ major ADGs
- 5040 10+ Other ADG Combinations, Age >18, 0-1 major ADG
- 5050 10+ Other ADG Combinations, Age >18, 2 major ADGs
- 5060 10+ Other ADG Combinations, Age >18, 3 major ADGs
- 5070 10+ Other ADG Combinations, Age >18, 4+ major ADGs

Appendix B: PROSSER's Algorithm

The following SPSS algorithm was developed by Dr. Bob Prosser specifically for this study. It produces bootstrap samples, computes proportions of 1s for 5 indicator variables and tests 3 trend components (linear, quadratic and cubic) for these proportions. The significance testing performed in the algorithm takes into account the dependence among the proportions.

*** **Step 1**: Open your data file. (The following GET FILE command is an example.)

```
GET FILE='K:\December 7 (N=20,242).sav'.
```

*** **Step 2**: Create a folder c:\testing on your c:\ drive.

*** **Step 3**: Chose the five variables you will work with (e.g. HbA1c for each of the five years) and insert their names in in the following commands.

*** Then run these commands.

```
compute var1a = HbA1c1.
compute var2a = HbA1c2.
compute var3a = HbA1c3.
compute var4a = HbA1c4.
compute var5a = HbA1c5.
execute.
```

*** **Step 4**: create a new variable called ONE in your data file.

```
compute one = 1.
execute.
```

*** **Step 5**: Save the data file in c:\testing . (The following is an example.)

```
SAVE OUTFILE='C:\testing\boot_test.sav'.
```

*** **Step 6**: Define the macro for doing the bootstrap sampling and computation of proportions by.
*** running the following commands (i.e., every line from DEFINE to !ENDDEFINE, inclusive).

```
DEFINE trend_test_bootstrap (samples=!TOKENS(1) /size =!CMDEND)

!DO !other=1 !TO !samples

SET SEED RANDOM.
WEIGHT OFF.
FILTER OFF.
DO IF $casenum=1.
- COMPUTE #samplesize=!size.
- COMPUTE #filesize=!size.
END IF.
DO IF (#samplesize>0 and #filesize>0).
- COMPUTE sampleWeight=rv.binom(#samplesize, 1/#filesize).
- COMPUTE #samplesize=#samplesize-sampleWeight.
- COMPUTE #filesize=#filesize-1.
ELSE.
- COMPUTE sampleWeight=0.
END IF.

WEIGHT BY sampleWeight.
FILTER BY sampleWeight.

MEANS
  TABLES = var1a var2a var3a var4a var5a  BY one
  /CELLS MEAN  .

!DOEND
!ENDDEFINE.
```

*** **Step 7**: Run the following commands to set up a file (called out1.sav) to collect up the output from each bootstrap iteration.
*** These OMS commands tell SPSS to save all the output tables from the MEANS procedure into a file for use as data later.

```
PRESERVE.
SET TVARS NAMES.

* The first OMS command just suppresses Viewer output.

OMS /DESTINATION VIEWER=NO /TAG='suppressall'.

* Select MEANS output table and write to data file called c:\testing\out1.sav.

OMS
```

```
 /SELECT TABLES
 /IF COMMANDS = ["Means"]
    SUBTYPES = ["Report"]
 /DESTINATION FORMAT = SAV NUMBERED = TableNumber_
  OUTFILE = "C:\testing\out1.sav".


*** Step 8: Call the macro defined earlier, and specify number of samples to draw.
*** Usually we'd set samples = 1000.
*** Also, specify the number of cases in your original data file: size = # of cases.

trend_test_bootstrap
   samples=1000
   size = 20242.

* The OMSEND command finishes up the writing of the data to out1.sav .

OMSEND.


*** Step 9: Open and clean up the output file.

GET FILE 'c:\testing\out1.sav'.

select if (substr(var1,1,1) = '1').
rename variables (tablenumber_ = sample_number).
execute.
delete variables command_ subtype_ label_ var1 var2.

SAVE OUTFILE = "C:\testing\out1.sav".


*** Step 10: Compute the values of linear, quadratic & cubic trends in the five proportions.

compute linear = 2 * var5a + var4a - var2a - (2 * var1a).
compute quad = 2 * var5a + 2 * var1a - var4a - var2a - (2 * var3a).
compute cubic = var5a + (2 * var2a) - var1a - (2 * var4a).

formats linear quad cubic (f8.4).


*** Step 11: Test the significance of each component of trend by looking at the sampling
distributions.
*** and tail cutoff values of the three statistics.

FREQUENCIES
```

```
  VARIABLES= linear quad cubic
  /FORMAT NOTABLE
  /STATISTICS = MEAN STDDEV
  /PERCENTILES= 2.5 97.5
  /HISTOGRAM NORMAL.

RESTORE.
***************
```

Appendix C: Description of Individual Adherence Variables

Haemoglobin A1c Test

Information on the proportion of adults with diagnosed type 2 diabetes who received two or more HbA1c tests per fiscal year is provided in table C-1. The proportion of adults with diagnosed type 2 diabetes who received two or more HbA1c tests per fiscal year increased from 34.8% in 1996/97 to 51.7% in 2000/01. The difference between these two proportions is highly significant (McNemar test, Chi-square = 1,434, $p<.001$). Indeed, a significant increase was observed in each year ($p<.001$).

Table C-1 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving 2 or More HbA1c Tests per Year

	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	34.7%	34.1%	35.3%	43.0%	42.4%	43.7%	45.7%	45.0%	46.3%	49.2%	48.5%	49.8%	51.0%	50.3%	51.6%
By Sex															
Female	35.2%	34.3%	36.1%	43.6%	42.6%	44.5%	45.3%	44.3%	46.2%	49.5%	48.5%	50.4%	51.0%	50.0%	51.9%
Male	34.3%	33.5%	35.1%	42.5%	41.6%	43.4%	49.4%	48.5%	50.3%	48.9%	48.0%	49.8%	51.0%	50.1%	51.9%
By Age															
20-29	26.4%	22.4%	30.9%	36.5%	31.7%	41.6%	37.9%	32.5%	43.6%	43.1%	37.0%	49.4%	35.4%	29.0%	42.5%
30-39	27.1%	24.8%	29.5%	37.1%	34.4%	39.8%	38.7%	35.8%	41.6%	41.3%	38.2%	44.4%	45.1%	41.9%	48.5%
40-49	30.2%	28.7%	31.8%	39.8%	38.2%	41.6%	42.1%	40.3%	43.9%	45.1%	43.2%	47.0%	45.0%	43.0%	47.0%
50-59	33.5%	32.2%	34.8%	41.5%	40.2%	42.9%	45.9%	44.6%	47.3%	49.5%	48.1%	50.9%	50.6%	49.2%	52.0%
60-69	38.5%	37.3%	39.6%	46.1%	44.9%	47.3%	48.3%	47.1%	49.5%	51.9%	50.7%	53.2%	55.4%	54.2%	56.6%
70-79	37.9%	36.5%	39.3%	46.1%	44.7%	47.5%	47.5%	46.1%	48.8%	50.8%	49.5%	52.1%	53.4%	52.1%	54.7%
80+	31.0%	28.3%	33.9%	37.0%	34.4%	39.7%	40.9%	38.5%	43.4%	44.8%	42.6%	47.1%	43.0%	41.0%	45.1%
By Socio-Economic Status															
Quintile 1 (Low)	32.5%	31.1%	33.8%	40.0%	38.7%	41.5%	42.8%	41.4%	44.2%	47.2%	45.8%	48.5%	49.4%	48.0%	50.8%
Quintile 2	33.5%	32.1%	34.8%	42.1%	40.8%	43.6%	44.1%	42.7%	45.5%	48.0%	46.6%	49.4%	49.2%	47.8%	50.6%
Quintile 3	35.2%	33.9%	36.5%	43.4%	42.0%	44.7%	45.5%	44.2%	46.9%	49.8%	48.4%	51.2%	52.1%	50.7%	53.5%
Quintile 4	37.1%	35.7%	38.6%	45.9%	44.4%	47.4%	48.9%	47.5%	50.4%	50.2%	48.8%	51.7%	51.4%	49.9%	52.8%
Quintile 5 (High)	38.2%	36.4%	40.1%	45.6%	43.8%	47.4%	49.4%	47.6%	51.2%	52.5%	50.6%	54.3%	54.8%	53.0%	56.6%
By Morbidity															
Very Low	29.9%	25.4%	34.9%	35.6%	30.8%	40.8%	40.7%	35.7%	46.0%	39.9%	34.9%	45.1%	47.0%	41.9%	52.2%
Low	32.2%	30.4%	34.2%	40.9%	38.9%	42.9%	40.6%	38.6%	42.6%	45.5%	43.5%	47.6%	48.4%	46.4%	50.4%
Medium	33.1%	31.8%	34.4%	40.8%	39.4%	42.2%	44.3%	42.9%	45.7%	47.6%	46.2%	49.0%	49.6%	48.2%	51.1%
High	35.6%	34.6%	36.6%	44.7%	43.6%	45.8%	47.3%	46.2%	48.3%	51.3%	50.3%	52.4%	52.0%	50.9%	53.1%
Very High	36.2%	35.1%	37.4%	43.9%	42.8%	45.1%	47.0%	45.8%	48.2%	49.6%	48.4%	50.8%	52.1%	50.9%	53.3%
By Disease-Specific Severity Index															
No Complications	32.7%	31.6%	33.8%	40.0%	38.9%	41.2%	42.8%	41.7%	44.0%	45.0%	43.9%	46.2%	47.6%	46.4%	48.8%
1 or More Minor Complications	33.3%	32.3%	34.4%	43.0%	41.9%	44.1%	45.5%	44.4%	46.6%	50.3%	49.2%	51.5%	51.5%	50.3%	52.6%
1 or More Intermediate Complications	37.2%	36.1%	38.3%	45.3%	44.1%	46.4%	47.7%	46.6%	48.9%	51.6%	50.5%	52.8%	53.1%	52.0%	54.3%
1 Major Complication	36.0%	31.7%	40.7%	45.5%	40.9%	50.2%	47.8%	43.1%	52.5%	48.5%	43.8%	53.2%	47.8%	43.1%	52.5%
2 or More Major Complications	44.4%	40.5%	48.5%	48.6%	44.7%	52.7%	55.2%	51.2%	59.2%	53.7%	49.7%	57.7%	59.6%	55.6%	63.5%
By Patient Residence															
LHA 202 - S. Surrey / WR	37.2%	34.5%	40.0%	52.6%	49.8%	55.4%	54.7%	51.9%	57.5%	56.6%	53.9%	59.4%	60.9%	58.2%	63.6%
LHA 201 - Surrey	32.1%	30.8%	33.3%	39.6%	38.3%	41.0%	41.4%	40.1%	42.7%	45.6%	44.2%	46.9%	47.8%	46.5%	49.2%
LHA 076 - Agassiz-Harrison	16.8%	11.4%	24.1%	32.3%	24.9%	40.8%	39.5%	31.5%	48.2%	43.8%	35.6%	52.4%	47.0%	38.8%	55.4%
LHA 075 - Mission	23.7%	20.5%	27.2%	32.9%	29.3%	36.7%	38.4%	34.6%	42.3%	38.4%	34.6%	42.3%	47.4%	43.5%	51.4%
LHA 043 - Coquitlam	38.0%	36.2%	39.8%	44.7%	42.8%	46.6%	48.4%	46.5%	50.3%	52.3%	50.4%	54.2%	52.9%	51.0%	54.8%
LHA 042 - Maple Ridge	32.1%	29.5%	34.9%	38.8%	36.1%	41.7%	38.2%	35.5%	41.0%	44.2%	41.5%	47.1%	43.8%	41.0%	46.6%
LHA 041 - Burnaby	41.1%	39.5%	42.6%	47.8%	46.2%	49.4%	50.8%	49.2%	52.4%	55.0%	53.4%	56.6%	56.0%	54.4%	57.6%
LHA 040 - New Westminster	37.1%	34.3%	40.1%	47.8%	44.9%	50.8%	50.5%	47.5%	53.5%	54.4%	51.4%	57.3%	54.9%	52.0%	57.9%
LHA 037 - Delta	35.3%	33.0%	37.7%	43.0%	40.6%	45.4%	45.3%	42.9%	47.8%	49.6%	47.1%	52.1%	52.9%	50.4%	55.4%
LHA 035 - Langley	37.8%	35.5%	40.1%	46.4%	44.1%	48.8%	47.2%	44.9%	49.5%	52.4%	50.0%	54.7%	53.4%	51.1%	55.7%
LHA 034 - Abbotsford	29.7%	27.8%	31.7%	38.5%	36.5%	40.6%	43.1%	41.0%	45.2%	42.4%	40.4%	44.6%	44.0%	42.0%	46.2%
LHA 033 - Chilliwack	26.1%	23.7%	28.7%	39.5%	36.8%	42.3%	45.1%	42.3%	47.9%	46.9%	44.1%	49.7%	47.7%	45.0%	50.6%
LHA 032 - Hope	40.4%	32.8%	48.5%	34.4%	27.3%	42.3%	35.3%	28.1%	43.3%	41.3%	33.8%	49.3%	47.4%	39.7%	55.3%

Eye Exam

Information on the proportion of adults with diagnosed type 2 diabetes who received at least one eye exam per fiscal year is provided in table C-2. The proportion of adults with diagnosed type 2 diabetes who received at least one eye exam per fiscal year increased from 35.9% in 1996/97 to 39.4% in 2000/01. The difference between these two proportions is highly significant (McNemar test, Chi-square = 70, $p<.001$). Unlike the results for two or more HbA1c

tests, the changes over time for an annual eye exam are more mixed. A significant increase in the proportion of adults with diagnosed type 2 diabetes who received at least one eye exam per fiscal year was seen between 1996/97 and 1997/98 (McNemar test, Chi-square = 101, p<.001). After 1997/98, no significant changes in the proportion were observed in any of the following years (compared to 1997/98).

Table C-2 Proportion of Adults with Diagnosed Type 2 Diabetes Receiving At Least One Eye Exam per Year

	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	36.9%	36.3%	37.6%	40.9%	40.3%	41.6%	40.4%	39.8%	41.1%	41.3%	40.6%	41.9%	39.3%	38.7%	39.9%
By Sex															
Female	39.5%	38.6%	40.4%	43.3%	42.4%	44.3%	42.5%	41.5%	43.4%	43.5%	42.6%	44.5%	41.3%	40.3%	42.2%
Male	34.6%	33.8%	35.5%	38.9%	38.0%	39.7%	38.6%	37.7%	39.5%	39.3%	38.4%	40.1%	37.6%	36.7%	38.4%
By Age															
20-29	30.8%	26.5%	35.4%	32.9%	28.2%	37.9%	32.8%	27.6%	38.4%	36.0%	30.2%	42.2%	24.9%	19.3%	31.5%
30-39	25.5%	23.3%	27.9%	29.5%	27.0%	32.1%	27.4%	24.8%	30.1%	29.3%	26.6%	32.2%	29.1%	26.2%	32.2%
40-49	28.1%	26.6%	29.6%	32.6%	31.0%	34.3%	31.5%	29.8%	33.2%	32.1%	30.3%	33.9%	29.5%	27.7%	31.4%
50-59	31.4%	30.2%	32.7%	35.7%	34.4%	37.0%	35.2%	33.9%	36.5%	35.3%	34.0%	36.7%	33.0%	31.7%	34.3%
60-69	39.8%	38.7%	41.0%	44.1%	42.9%	45.3%	43.4%	42.2%	44.6%	44.8%	43.6%	46.0%	41.6%	40.4%	42.8%
70-79	47.5%	46.0%	48.9%	49.2%	47.8%	50.6%	48.1%	46.8%	49.5%	47.4%	46.1%	48.7%	47.1%	45.8%	48.3%
80+	47.7%	44.7%	50.8%	48.7%	46.0%	51.5%	46.6%	44.2%	49.1%	46.3%	44.0%	48.6%	41.9%	39.9%	43.9%
By Socio-Economic Status															
Quintile 1 (Low)	35.9%	34.5%	37.3%	40.9%	39.5%	42.3%	39.9%	38.5%	41.3%	40.9%	39.6%	42.3%	40.1%	38.7%	41.5%
Quintile 2	36.5%	35.1%	37.9%	40.1%	38.7%	41.5%	40.1%	38.7%	41.4%	40.6%	39.3%	42.0%	39.4%	38.0%	40.7%
Quintile 3	35.5%	34.1%	36.8%	39.6%	38.3%	41.0%	39.0%	37.7%	40.4%	40.9%	39.6%	42.3%	38.1%	36.7%	39.5%
Quintile 4	38.6%	37.1%	40.1%	42.7%	41.2%	44.1%	41.8%	40.4%	43.3%	41.4%	39.9%	42.8%	40.2%	38.8%	41.6%
Quintile 5 (High)	39.1%	37.3%	41.0%	42.0%	40.3%	43.8%	42.6%	40.9%	44.4%	42.9%	41.1%	44.8%	38.9%	37.1%	40.7%
By Morbidity															
Very Low	21.7%	17.7%	26.3%	22.2%	18.2%	26.9%	16.5%	13.0%	20.8%	17.9%	14.3%	22.3%	27.1%	22.7%	32.0%
Low	28.3%	26.5%	30.1%	31.1%	29.3%	33.0%	27.9%	26.1%	29.7%	29.4%	27.6%	31.3%	33.1%	31.2%	35.0%
Medium	30.8%	29.6%	32.2%	34.5%	33.2%	35.9%	32.9%	31.6%	34.2%	34.6%	33.3%	36.0%	34.9%	33.6%	36.3%
High	38.3%	37.3%	39.4%	42.8%	41.8%	43.9%	42.4%	41.4%	43.5%	43.2%	42.1%	44.2%	40.2%	39.2%	41.3%
Very High	43.7%	42.6%	44.9%	47.9%	46.8%	49.1%	49.4%	48.2%	50.6%	49.4%	48.2%	50.6%	44.4%	43.3%	45.6%
By Disease-Specific Severity Index															
No Complications	30.0%	29.0%	31.1%	32.8%	31.7%	33.9%	30.1%	29.1%	31.2%	31.2%	30.1%	32.3%	32.4%	31.3%	33.5%
1 or More Minor Complications	31.2%	30.2%	32.3%	34.9%	33.8%	35.9%	31.1%	30.1%	32.2%	32.3%	31.3%	33.4%	34.1%	33.0%	35.2%
1 or More Intermediate Complications	47.7%	46.5%	48.8%	52.9%	51.8%	54.1%	58.2%	57.0%	59.3%	58.6%	57.5%	59.7%	50.7%	49.5%	51.8%
1 Major Complication	52.4%	47.7%	57.1%	58.2%	53.5%	62.8%	58.4%	53.7%	63.0%	52.4%	47.7%	57.1%	47.6%	42.9%	52.3%
2 or More Major Complications	49.0%	45.0%	53.0%	55.9%	51.9%	59.9%	51.5%	47.5%	55.5%	53.7%	49.7%	57.7%	42.2%	38.3%	46.3%
By Patient Residence															
LHA 202 - S. Surrey / WR	44.2%	41.4%	47.0%	50.1%	47.3%	52.9%	47.7%	44.9%	50.5%	48.5%	45.7%	51.3%	45.7%	42.9%	48.4%
LHA 201 - Surrey	31.3%	30.0%	32.5%	35.0%	33.8%	36.3%	35.9%	34.6%	37.2%	35.5%	34.3%	36.8%	35.7%	34.4%	37.0%
LHA 076 - Agassiz-Harrison	29.8%	22.6%	38.1%	44.6%	36.4%	53.2%	44.2%	35.9%	52.8%	43.8%	35.6%	52.4%	40.3%	32.4%	48.8%
LHA 075 - Mission	33.5%	29.9%	37.3%	41.7%	37.9%	45.7%	37.4%	33.7%	41.3%	36.9%	33.2%	40.9%	36.5%	32.8%	40.3%
LHA 043 - Coquitlam	34.6%	32.9%	36.5%	39.5%	37.6%	41.3%	38.7%	36.8%	40.5%	37.8%	36.0%	39.7%	38.3%	36.5%	40.2%
LHA 042 - Maple Ridge	32.2%	29.6%	35.0%	34.3%	31.7%	37.1%	30.6%	28.1%	33.3%	33.5%	30.9%	36.2%	32.0%	29.4%	34.6%
LHA 041 - Burnaby	40.0%	38.5%	41.6%	44.3%	42.7%	45.9%	43.5%	42.0%	45.1%	47.0%	45.4%	48.6%	44.7%	43.1%	46.4%
LHA 040 - New Westminster	44.9%	42.0%	47.9%	50.0%	47.1%	53.0%	51.5%	48.6%	54.5%	50.7%	47.8%	53.7%	47.3%	44.3%	50.3%
LHA 037 - Delta	34.0%	31.7%	36.4%	35.3%	33.0%	37.7%	34.6%	32.2%	37.0%	35.7%	33.4%	38.2%	34.2%	31.9%	36.7%
LHA 035 - Langley	50.1%	47.7%	52.4%	50.5%	48.1%	52.8%	53.6%	51.3%	55.9%	53.0%	50.7%	55.4%	49.2%	46.8%	51.5%
LHA 034 - Abbotsford	36.6%	34.5%	38.7%	40.0%	37.9%	42.1%	37.8%	35.8%	39.9%	39.9%	37.8%	42.0%	33.6%	31.6%	35.6%
LHA 033 - Chilliwack	36.8%	34.1%	39.6%	44.4%	41.6%	47.3%	43.1%	40.3%	45.9%	44.8%	42.1%	47.7%	38.5%	35.8%	41.3%
LHA 032 - Hope	25.3%	19.0%	33.0%	33.1%	26.1%	41.0%	28.0%	21.4%	35.7%	25.3%	19.1%	32.9%	37.7%	30.4%	45.5%

Microalbumin Test

Information on the proportion of adults with diagnosed type 2 diabetes who received at least one urinary microalbumin test per fiscal year is provided in table C-3. The proportion of adults with diagnosed type 2 diabetes who received at least one urinary microalbumin test per fiscal year increased from 13.2% in 1996/97 to 37.6% in 2000/01. The difference between these two proportions is highly significant (McNemar test, Chi-square = 3,280, $p<.001$). Indeed, a significant increase was observed in each year ($p<.001$).

Table C-3 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving At Least One Microalbumin Test per Year

	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	12.7%	12.3%	13.2%	19.6%	19.0%	20.1%	24.7%	24.2%	25.3%	32.6%	32.0%	33.2%	35.9%	35.2%	36.5%
By Sex															
Female	12.2%	11.6%	12.9%	18.8%	18.0%	19.5%	24.2%	23.4%	25.0%	30.9%	30.0%	31.8%	34.7%	33.8%	35.6%
Male	13.2%	12.6%	13.8%	20.3%	19.6%	21.0%	25.3%	24.5%	26.0%	34.2%	33.4%	35.1%	36.9%	36.1%	37.8%
By Age															
20-29	16.3%	13.1%	20.2%	22.8%	18.7%	27.4%	31.0%	26.0%	36.6%	40.2%	34.2%	46.5%	38.1%	31.5%	45.2%
30-39	15.7%	13.8%	17.7%	23.1%	20.8%	25.5%	26.8%	24.3%	29.5%	35.1%	32.2%	38.1%	37.6%	34.4%	40.8%
40-49	13.4%	12.3%	14.6%	21.1%	19.7%	22.6%	27.5%	25.9%	29.2%	35.0%	33.2%	36.8%	38.5%	36.6%	40.5%
50-59	14.3%	13.4%	15.3%	21.5%	20.4%	22.6%	27.5%	26.3%	28.7%	36.5%	35.2%	37.8%	39.9%	38.5%	41.3%
60-69	13.1%	12.3%	13.9%	20.6%	19.6%	21.6%	25.9%	24.9%	27.0%	36.2%	35.1%	37.4%	38.8%	37.6%	40.0%
70-79	10.4%	9.5%	11.3%	16.6%	15.6%	17.7%	21.8%	20.7%	22.9%	28.5%	27.3%	29.7%	34.0%	32.8%	35.2%
80+	4.9%	3.7%	6.4%	9.4%	7.9%	11.1%	12.9%	11.3%	14.7%	16.9%	15.2%	18.6%	20.4%	18.8%	22.1%
By Socio-Economic Status															
Quintile 1 (Low)	12.4%	11.5%	13.3%	18.0%	16.9%	19.1%	22.4%	21.2%	23.6%	29.8%	28.5%	31.1%	33.4%	32.1%	34.7%
Quintile 2	13.0%	12.0%	14.0%	18.7%	17.6%	19.8%	24.4%	23.2%	25.6%	32.2%	30.9%	33.5%	34.5%	33.2%	35.9%
Quintile 3	13.3%	12.3%	14.2%	19.7%	18.6%	20.8%	25.3%	24.1%	26.5%	33.8%	32.5%	35.2%	37.2%	35.8%	38.6%
Quintile 4	12.5%	11.5%	13.5%	21.7%	20.5%	22.9%	25.8%	24.5%	27.1%	34.9%	33.5%	36.3%	37.1%	35.7%	38.5%
Quintile 5 (High)	12.6%	11.4%	13.9%	19.9%	18.5%	21.4%	26.3%	24.8%	27.9%	33.2%	31.5%	35.0%	37.7%	35.9%	39.5%
By Morbidity															
Very Low	8.0%	5.6%	11.3%	23.4%	19.2%	28.1%	25.9%	21.6%	30.8%	29.9%	25.4%	34.9%	35.9%	31.1%	41.1%
Low	13.2%	11.9%	14.6%	20.4%	18.8%	22.1%	25.7%	24.0%	27.6%	34.9%	32.9%	36.8%	38.9%	37.0%	40.9%
Medium	12.1%	11.2%	13.0%	19.4%	18.3%	20.6%	25.1%	23.9%	26.4%	35.5%	34.2%	36.9%	39.1%	37.8%	40.5%
High	13.3%	12.6%	14.0%	20.2%	19.4%	21.1%	25.4%	24.4%	26.3%	33.5%	32.5%	34.5%	35.9%	34.9%	37.0%
Very High	12.7%	11.9%	13.5%	18.4%	17.5%	19.3%	23.4%	22.4%	24.5%	29.0%	28.0%	30.1%	32.6%	31.5%	33.7%
By Disease-Specific Severity Index															
No Complications	13.0%	12.2%	13.8%	19.9%	19.0%	20.9%	25.3%	24.3%	26.3%	33.1%	32.0%	34.2%	37.0%	35.9%	38.1%
1 or More Minor Complications	12.4%	11.7%	13.2%	19.4%	18.6%	20.3%	24.8%	23.9%	25.8%	34.4%	33.3%	35.5%	36.7%	35.7%	37.9%
1 or More Intermediate Complications	12.5%	11.8%	13.3%	19.4%	18.5%	20.3%	24.2%	23.2%	25.2%	31.4%	30.4%	32.5%	35.5%	34.4%	36.6%
1 Major Complication	16.4%	13.2%	20.2%	22.6%	18.9%	26.8%	26.6%	22.6%	30.9%	27.9%	23.9%	32.4%	28.4%	24.4%	32.8%
2 or More Major Complications	13.5%	11.0%	16.5%	16.9%	14.1%	20.1%	23.0%	19.8%	26.5%	21.8%	18.7%	25.3%	20.8%	17.7%	24.2%
By Patient Residence															
LHA 202 - S. Surrey / WR	9.3%	7.8%	11.0%	14.5%	12.6%	16.6%	25.8%	23.4%	28.3%	33.5%	30.9%	36.2%	46.0%	43.2%	48.8%
LHA 201 - Surrey	14.0%	13.1%	15.0%	21.5%	20.5%	22.7%	26.5%	25.3%	27.7%	36.7%	35.5%	38.0%	39.8%	38.5%	41.1%
LHA 076 - Agassiz-Harrison	8.4%	4.8%	14.4%	28.5%	21.4%	36.8%	38.0%	30.1%	46.6%	49.2%	40.8%	57.7%	47.0%	38.8%	55.4%
LHA 075 - Mission	12.4%	10.0%	15.3%	14.9%	12.3%	17.9%	19.3%	16.4%	22.7%	25.6%	22.3%	29.2%	33.7%	30.1%	37.5%
LHA 043 - Coquitlam	12.5%	11.3%	13.8%	19.2%	17.8%	20.7%	21.3%	19.8%	22.9%	31.7%	30.0%	33.5%	36.0%	34.2%	37.8%
LHA 042 - Maple Ridge	13.8%	12.0%	15.9%	19.5%	17.4%	21.9%	21.3%	19.1%	23.8%	32.2%	29.6%	34.9%	32.5%	29.9%	35.1%
LHA 041 - Burnaby	12.5%	11.5%	13.6%	18.8%	17.6%	20.1%	22.5%	21.2%	23.9%	29.6%	28.2%	31.1%	32.0%	30.5%	33.6%
LHA 040 - New Westminster	10.8%	9.1%	12.8%	14.3%	12.3%	16.5%	18.8%	16.5%	21.2%	24.6%	22.1%	27.3%	27.8%	25.3%	30.6%
LHA 037 - Delta	12.4%	10.9%	14.1%	21.8%	19.8%	23.9%	27.7%	25.6%	30.0%	34.1%	31.8%	36.5%	36.5%	34.1%	38.9%
LHA 035 - Langley	14.1%	12.5%	15.8%	23.0%	21.1%	25.0%	29.1%	27.0%	31.2%	37.3%	35.0%	39.6%	39.2%	36.9%	41.5%
LHA 034 - Abbotsford	12.7%	11.4%	14.3%	17.5%	15.9%	19.2%	22.7%	21.0%	24.5%	26.1%	24.3%	28.0%	26.2%	24.4%	28.1%
LHA 033 - Chilliwack	10.1%	8.5%	12.0%	20.2%	18.0%	22.6%	32.9%	30.3%	35.6%	36.0%	33.3%	38.7%	41.4%	38.7%	44.2%
LHA 032 - Hope	21.9%	16.0%	29.3%	25.2%	18.9%	32.7%	32.0%	25.1%	39.8%	36.7%	29.4%	44.6%	35.7%	28.6%	43.5%

Lipid Test

Information on the proportion of adults with diagnosed type 2 diabetes who received at least one lipid test every three years is provided in table C-4. The proportion of adults with diagnosed type 2 diabetes who received at least one lipid test every three years increased from 77.1% in 1996/97-1998/99 to 82.2% in 1998/99-2000/01. The difference between these two

proportions is highly significant (McNemar test, Chi-square = 269, p<.001). Indeed, a significant increase was observed during each three year period (p<.001).

Table C-4 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving At Least One Lipid Test Every Three Years

	96/97 - 98/99			97/98 - 99/00			98/99 - 00/01		
	%	95% CI		%	95% CI		%	95% CI	
Total Population	74.1%	73.6%	74.7%	77.4%	76.9%	78.0%	79.1%	78.6%	79.6%
By Sex									
Female	70.7%	69.9%	71.6%	74.1%	73.2%	74.9%	75.8%	75.0%	76.6%
Male	77.3%	76.5%	78.0%	80.5%	79.7%	81.2%	82.1%	81.4%	82.8%
By Age									
20-29	56.0%	51.2%	60.7%	59.0%	53.2%	64.5%	55.6%	48.4%	62.5%
30-39	69.8%	67.3%	72.1%	70.5%	67.7%	73.1%	69.6%	66.5%	72.6%
40-49	79.7%	78.3%	81.0%	81.6%	80.2%	83.0%	81.7%	80.1%	83.2%
50-59	82.4%	81.4%	83.4%	85.1%	84.1%	86.0%	86.8%	85.8%	87.7%
60-69	80.0%	79.0%	81.0%	85.3%	84.4%	86.2%	87.4%	86.5%	88.2%
70-79	64.1%	62.8%	65.5%	71.3%	70.1%	72.5%	77.7%	76.6%	78.8%
80+	32.7%	29.9%	35.6%	40.3%	37.9%	42.8%	46.6%	44.6%	48.7%
By Socio-Economic Status									
Quintile 1 (Low)	71.0%	69.6%	72.2%	73.4%	72.2%	74.7%	75.3%	74.1%	76.5%
Quintile 2	73.2%	72.0%	74.5%	77.2%	76.1%	78.4%	78.0%	76.8%	79.1%
Quintile 3	75.2%	74.0%	76.4%	78.7%	77.5%	79.8%	81.2%	80.1%	82.3%
Quintile 4	77.0%	75.7%	78.2%	79.3%	78.1%	80.5%	80.9%	79.7%	82.0%
Quintile 5 (High)	76.5%	74.9%	78.1%	81.0%	79.5%	82.3%	82.1%	80.7%	83.5%
By Morbidity									
Very Low	70.4%	65.4%	74.9%	72.9%	68.1%	77.3%	76.1%	71.3%	80.2%
Low	72.1%	70.3%	73.9%	75.1%	73.3%	76.9%	78.2%	76.5%	79.9%
Medium	75.0%	73.7%	76.2%	78.9%	77.7%	80.0%	80.9%	79.7%	82.0%
High	74.6%	73.7%	75.5%	78.0%	77.1%	78.9%	79.6%	78.8%	80.5%
Very High	74.5%	73.4%	75.5%	77.3%	76.3%	78.3%	78.4%	77.4%	79.4%
By Disease-Specific Severity Index									
No Complications	69.9%	68.8%	71.0%	73.2%	72.1%	74.2%	75.7%	74.7%	76.7%
1 or More Minor Complications	78.7%	77.8%	79.6%	82.0%	81.1%	82.9%	83.2%	82.4%	84.1%
1 or More Intermediate Complications	73.7%	72.7%	74.7%	76.9%	75.9%	77.9%	78.3%	77.3%	79.2%
1 Major Complication	68.6%	64.1%	72.8%	72.1%	67.7%	76.1%	75.1%	70.8%	78.9%
2 or More Major Complications	75.2%	71.5%	78.5%	78.7%	75.2%	81.8%	79.1%	75.6%	82.1%
By Patient Residence									
LHA 202 - S. Surrey / WR	68.2%	65.5%	70.7%	71.6%	69.0%	74.1%	75.8%	73.3%	78.1%
LHA 201 - Surrey	75.8%	74.6%	76.9%	78.3%	77.1%	79.4%	80.7%	79.6%	81.8%
LHA 076 - Agassiz-Harrison	65.6%	57.2%	73.2%	72.1%	63.8%	79.1%	79.1%	71.5%	85.1%
LHA 075 - Mission	66.3%	62.5%	70.0%	72.5%	68.9%	75.9%	75.8%	72.3%	79.0%
LHA 043 - Coquitlam	74.9%	73.3%	76.5%	78.9%	77.3%	80.4%	79.9%	78.4%	81.4%
LHA 042 - Maple Ridge	75.6%	73.1%	78.0%	78.1%	75.6%	80.4%	79.0%	76.6%	81.2%
LHA 041 - Burnaby	78.7%	77.3%	79.9%	80.6%	79.3%	81.9%	81.8%	80.5%	83.0%
LHA 040 - New Westminster	71.4%	68.6%	74.0%	75.4%	72.7%	77.8%	74.6%	71.9%	77.1%
LHA 037 - Delta	77.6%	75.5%	79.6%	80.7%	78.6%	82.6%	82.2%	80.2%	84.0%
LHA 035 - Langley	71.9%	69.8%	74.0%	75.6%	73.5%	77.5%	77.7%	75.7%	79.5%
LHA 034 - Abbotsford	71.2%	69.2%	73.1%	75.2%	73.3%	77.0%	75.7%	73.8%	77.5%
LHA 033 - Chilliwack	66.9%	64.1%	69.5%	72.6%	70.0%	75.1%	75.1%	72.6%	77.4%
LHA 032 - Hope	68.5%	60.6%	75.5%	79.3%	72.2%	85.0%	82.5%	75.7%	87.7%

Blood Pressure Measurements

Information on the proportion of adults with diagnosed type 2 diabetes who received at least four blood pressure (BP) measurements per fiscal year is provided in table C-5. The proportion of adults with diagnosed type 2 diabetes who received at least four BP measurements per fiscal year increased from 80.5% in 1996/97 to 85.4% in 2000/01. The difference between these two proportions is highly significant (McNemar test, Chi-square = 224, p<.001). Like the results for at least one eye exam per year, the changes over time for at least four BP measurements per year are more mixed. A significant increase in the proportion of adults with diagnosed type 2 diabetes who received at least at least four BP measurements per fiscal year was seen between 1996/97 and 1997/98 (McNemar test, Chi-square = 167, p<.001). No significant change in the proportion was observed in the following year, with another significant increase between 1998/99 to 1999/00 (McNemar test, Chi-square = 36, p<.001). In 2000/01, however, there was a significant decrease in the proportion of adults with diagnosed type 2 diabetes who received at least four BP measurements (McNemar test, Chi-square = 5.6, p=.018).

Table C-5 Proportion of Adults with Diagnosed Type 2 Diabetes
With At Least Four Blood Pressure Measurements per Year

	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	81.0%	80.5%	81.5%	85.2%	84.7%	85.6%	84.9%	84.4%	85.3%	86.4%	86.0%	86.9%	85.6%	85.1%	86.0%
By Sex															
Female	85.8%	85.2%	86.5%	89.3%	88.7%	89.9%	88.2%	87.6%	88.8%	89.7%	89.1%	90.2%	88.3%	87.7%	88.9%
Male	76.8%	76.1%	77.6%	81.5%	80.8%	82.2%	81.9%	81.2%	82.6%	83.6%	82.9%	84.2%	83.1%	82.4%	83.8%
By Age															
20-29	71.2%	66.6%	75.3%	73.3%	68.5%	77.6%	76.2%	71.0%	80.8%	72.0%	66.0%	77.3%	70.4%	63.5%	76.4%
30-39	72.0%	69.6%	74.3%	78.9%	76.5%	81.1%	75.4%	72.8%	77.9%	76.0%	73.3%	78.6%	74.1%	71.1%	76.9%
40-49	75.4%	73.9%	76.8%	78.9%	77.4%	80.2%	78.3%	76.7%	79.7%	79.5%	77.9%	81.0%	80.2%	78.6%	81.8%
50-59	78.3%	77.1%	79.4%	82.9%	81.9%	83.9%	82.2%	81.1%	83.2%	83.4%	82.4%	84.4%	82.4%	81.3%	83.4%
60-69	83.5%	82.6%	84.4%	86.3%	85.5%	87.1%	86.3%	85.4%	87.1%	88.4%	87.6%	89.2%	86.6%	85.7%	87.4%
70-79	87.0%	86.0%	88.0%	90.6%	89.8%	91.4%	89.9%	89.1%	90.7%	90.8%	90.1%	91.6%	89.9%	89.1%	90.7%
80+	87.4%	85.2%	89.3%	92.5%	90.9%	93.8%	91.2%	89.7%	92.5%	91.4%	90.0%	92.6%	89.5%	88.2%	90.7%
By Socio-Economic Status															
Quintile 1 (Low)	84.8%	83.7%	85.8%	89.1%	88.2%	90.0%	88.9%	88.0%	89.8%	89.9%	89.0%	90.7%	89.3%	88.5%	90.2%
Quintile 2	83.3%	82.2%	84.3%	87.1%	86.2%	88.0%	86.7%	85.7%	87.6%	87.1%	86.1%	88.0%	86.4%	85.5%	87.4%
Quintile 3	81.3%	80.2%	82.4%	85.1%	84.1%	86.0%	85.3%	84.3%	86.2%	86.3%	85.3%	87.3%	86.2%	85.2%	87.2%
Quintile 4	78.4%	77.1%	79.6%	82.4%	81.3%	83.5%	81.4%	80.3%	82.5%	84.6%	83.6%	85.7%	82.8%	81.6%	83.9%
Quintile 5 (High)	75.5%	73.9%	77.1%	79.4%	77.9%	80.8%	79.6%	78.1%	81.0%	82.0%	80.6%	83.4%	81.1%	79.6%	82.5%
By Morbidity															
Very Low	53.6%	48.3%	58.7%	56.7%	51.5%	61.8%	43.9%	38.8%	49.1%	43.0%	37.9%	48.3%	57.8%	52.6%	62.9%
Low	63.5%	61.6%	65.5%	68.1%	66.2%	70.0%	55.5%	53.5%	57.5%	59.9%	57.9%	61.9%	68.2%	66.3%	70.1%
Medium	72.5%	71.3%	73.8%	79.2%	78.0%	80.3%	76.8%	75.6%	78.0%	78.9%	77.7%	80.0%	80.2%	79.1%	81.3%
High	82.8%	81.9%	83.6%	86.8%	86.1%	87.6%	89.1%	88.4%	89.8%	90.8%	90.2%	91.4%	87.6%	86.8%	88.3%
Very High	92.2%	91.5%	92.8%	94.6%	94.0%	95.1%	97.5%	97.1%	97.8%	97.7%	97.3%	98.0%	94.4%	93.8%	94.9%
By Disease-Specific Severity Index															
No Complications	72.2%	71.1%	73.2%	76.7%	75.7%	77.6%	74.0%	73.0%	75.1%	75.7%	74.6%	76.6%	77.0%	76.0%	78.0%
1 or More Minor Complications	84.1%	83.3%	85.0%	88.8%	88.0%	89.5%	89.4%	88.7%	90.1%	91.2%	90.6%	91.9%	89.5%	88.8%	90.2%
1 or More Intermediate Complications	85.6%	84.8%	86.4%	89.2%	88.5%	89.9%	89.9%	89.2%	90.6%	91.4%	90.8%	92.1%	89.6%	88.9%	90.3%
1 Major Complication	84.5%	80.8%	87.6%	85.9%	82.3%	88.9%	90.1%	86.9%	92.5%	88.9%	85.6%	91.5%	86.1%	82.6%	89.1%
2 or More Major Complications	86.7%	83.7%	89.2%	89.7%	87.0%	91.9%	89.7%	87.0%	91.9%	88.9%	86.1%	91.1%	86.8%	83.9%	89.3%
By Patient Residence															
LHA 202 - S. Surrey / WR	77.1%	74.7%	79.4%	80.2%	77.9%	82.4%	82.6%	80.4%	84.6%	84.8%	82.7%	86.7%	84.3%	82.2%	86.2%
LHA 201 - Surrey	83.9%	82.9%	84.9%	87.3%	86.4%	88.2%	87.4%	86.5%	88.3%	88.3%	87.5%	89.2%	87.8%	86.9%	88.7%
LHA 076 - Agassiz-Harrison	79.4%	71.7%	85.4%	88.5%	81.8%	92.9%	86.0%	79.0%	91.0%	88.5%	81.8%	92.9%	87.3%	80.6%	91.9%
LHA 075 - Mission	80.2%	76.9%	83.2%	87.9%	85.1%	90.2%	88.3%	85.5%	90.6%	87.2%	84.3%	89.6%	90.3%	87.7%	92.4%
LHA 043 - Coquitlam	78.1%	76.5%	79.7%	83.1%	81.7%	84.5%	82.7%	81.3%	84.1%	83.8%	82.4%	85.2%	82.5%	81.0%	83.9%
LHA 042 - Maple Ridge	82.4%	80.1%	84.5%	86.6%	84.5%	88.4%	84.2%	82.0%	86.2%	87.8%	85.9%	89.6%	87.9%	86.0%	89.6%
LHA 041 - Burnaby	80.2%	78.9%	81.5%	83.7%	82.5%	84.9%	83.6%	82.4%	84.8%	85.3%	84.2%	86.4%	85.4%	84.2%	86.5%
LHA 040 - New Westminster	81.0%	78.5%	83.2%	84.4%	82.1%	86.5%	85.7%	83.5%	87.7%	87.8%	85.7%	89.6%	85.0%	82.7%	87.0%
LHA 037 - Delta	80.7%	78.7%	82.5%	83.5%	81.6%	85.3%	81.5%	79.5%	83.4%	84.7%	82.8%	86.4%	83.2%	81.3%	85.0%
LHA 035 - Langley	79.7%	77.7%	81.5%	83.2%	81.4%	84.9%	82.9%	81.1%	84.6%	83.0%	81.2%	84.7%	78.1%	76.1%	80.0%
LHA 034 - Abbotsford	83.4%	81.7%	84.9%	88.6%	87.2%	89.9%	87.2%	85.7%	88.6%	89.1%	87.7%	90.3%	88.2%	86.7%	89.5%
LHA 033 - Chilliwack	78.5%	76.1%	80.8%	86.4%	84.3%	88.2%	85.3%	83.2%	87.2%	87.2%	85.2%	89.0%	88.5%	86.5%	90.1%
LHA 032 - Hope	80.1%	72.9%	85.8%	84.8%	78.2%	89.6%	86.0%	79.5%	90.7%	90.7%	85.0%	94.4%	89.6%	83.8%	93.5%

All Five Recommended Procedures

Information on the proportion of adults with diagnosed type 2 diabetes who received all five recommended procedures (two or more HbA1c tests, at least one eye exam, one microalbumin test and four BP measurements during each fiscal year, at least one lipid test every three years) each fiscal year is provided in table C-6. The proportion of adults with diagnosed type 2 diabetes who received all five procedures per fiscal year increased from 3.9% in 1996/97

to 10.7% in 2000/01. The difference between these two proportions is highly significant (McNemar test, Chi-square = 739, p<.001).

Between 1996/97 and 1997/98, the proportion of adults with diagnosed type 2 diabetes who received all five procedures per fiscal year increased from 3.9% to 6.1% (McNemar test, Chi-square = 116, p<.001). The following year the proportion increased to 7.0% (McNemar test, Chi-square = 16, p<.001), then 9.9% (McNemar test, Chi-square = 136, p<.001) and finally 10.7% (McNemar test, Chi-square = 7.9, p=.005). Indeed, a significant increase was observed in each year.

Table C-6 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving All Five Recommended Services

	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	3.7%	3.5%	4.0%	5.7%	5.4%	6.1%	6.6%	6.3%	7.0%	9.4%	9.0%	9.8%	10.1%	9.7%	10.5%
By Sex															
Female	3.9%	3.6%	4.3%	5.8%	5.3%	6.2%	6.7%	6.2%	7.2%	9.8%	9.2%	10.3%	10.6%	10.0%	11.2%
Male	3.6%	3.3%	3.9%	5.8%	5.4%	6.2%	6.6%	6.2%	7.1%	9.1%	8.6%	9.6%	9.7%	9.2%	10.3%
By Age															
20-29	3.6%	2.2%	5.9%	3.9%	2.4%	6.5%	6.2%	4.0%	9.6%	8.8%	5.8%	13.1%	7.4%	4.5%	12.1%
30-39	2.9%	2.1%	3.9%	4.3%	3.3%	5.6%	5.1%	3.9%	6.5%	7.6%	6.1%	9.4%	7.6%	6.0%	9.5%
40-49	3.3%	2.7%	3.9%	5.2%	4.5%	6.0%	5.4%	4.6%	6.3%	7.4%	6.5%	8.5%	7.9%	6.9%	9.1%
50-59	4.0%	3.5%	4.5%	6.1%	5.4%	6.7%	6.9%	6.2%	7.6%	9.8%	9.0%	10.6%	9.9%	9.1%	10.8%
60-69	4.7%	4.2%	5.3%	7.0%	6.4%	7.7%	8.2%	7.5%	8.9%	11.5%	10.7%	12.3%	11.8%	11.0%	12.7%
70-79	3.3%	2.8%	3.8%	5.6%	5.0%	6.3%	6.8%	6.2%	7.5%	9.7%	9.0%	10.5%	11.9%	11.2%	12.8%
80+	1.0%	0.5%	1.8%	1.8%	1.2%	2.7%	2.2%	1.6%	3.1%	4.3%	3.4%	5.3%	4.7%	3.9%	5.7%
By Socio-Economic Status															
Quintile 1 (Low)	3.5%	3.0%	4.0%	4.9%	4.3%	5.5%	5.7%	5.1%	6.4%	8.6%	7.9%	9.4%	9.4%	8.7%	10.3%
Quintile 2	3.7%	3.2%	4.2%	5.2%	4.6%	5.8%	6.7%	6.1%	7.5%	8.4%	7.7%	9.2%	9.7%	9.0%	10.6%
Quintile 3	3.8%	3.3%	4.3%	6.0%	5.4%	6.7%	6.8%	6.1%	7.5%	10.2%	9.3%	11.1%	10.8%	9.9%	11.7%
Quintile 4	4.2%	3.7%	4.9%	6.6%	5.9%	7.3%	7.1%	6.3%	7.8%	10.6%	9.7%	11.5%	10.6%	9.7%	11.5%
Quintile 5 (High)	3.8%	3.2%	4.7%	6.5%	5.7%	7.5%	7.1%	6.3%	8.1%	9.7%	8.7%	10.9%	10.5%	9.4%	11.7%
By Morbidity															
Very Low	0.9%	0.3%	2.5%	4.3%	2.6%	6.9%	1.4%	0.6%	3.3%	2.6%	1.4%	4.8%	7.7%	5.3%	11.0%
Low	2.9%	2.3%	3.7%	4.2%	3.5%	5.1%	3.4%	2.7%	4.2%	5.4%	4.5%	6.4%	8.1%	7.0%	9.3%
Medium	2.9%	2.5%	3.5%	5.0%	4.4%	5.6%	5.2%	4.6%	5.8%	7.7%	7.0%	8.5%	9.9%	9.1%	10.8%
High	3.8%	3.4%	4.3%	6.2%	5.7%	6.8%	7.3%	6.8%	7.9%	10.6%	10.0%	11.3%	10.3%	9.7%	11.0%
Very High	4.6%	4.1%	5.1%	6.4%	5.8%	7.0%	8.2%	7.6%	8.9%	10.9%	10.2%	11.7%	11.0%	10.3%	11.8%
By Disease-Specific Severity Index															
No Complications	3.2%	2.8%	3.6%	4.5%	4.1%	5.0%	4.9%	4.4%	5.5%	7.4%	6.8%	8.0%	8.5%	7.9%	9.2%
1 or More Minor Complications	3.4%	3.0%	3.8%	5.6%	5.1%	6.2%	6.3%	5.8%	6.9%	8.7%	8.1%	9.4%	9.8%	9.2%	10.5%
1 or More Intermediate Complications	4.4%	3.9%	4.9%	6.8%	6.2%	7.4%	8.3%	7.7%	9.0%	12.2%	11.5%	13.0%	12.2%	11.5%	13.0%
1 Major Complication	5.5%	3.8%	8.1%	9.2%	6.9%	12.3%	9.2%	6.9%	12.3%	8.8%	6.5%	11.8%	9.7%	7.3%	12.9%
2 or More Major Complications	5.7%	4.1%	7.9%	6.3%	4.6%	8.5%	8.8%	6.8%	11.3%	7.6%	5.7%	10.0%	6.9%	5.2%	9.3%
By Patient Residence															
LHA 202 - S. Surrey / WR	2.2%	1.5%	3.2%	4.1%	3.2%	5.4%	6.1%	4.9%	7.6%	9.6%	8.1%	11.4%	14.0%	12.2%	16.0%
LHA 201 - Surrey	3.8%	3.3%	4.4%	5.6%	5.0%	6.3%	6.6%	5.9%	7.3%	9.2%	8.5%	10.1%	10.8%	10.0%	11.6%
LHA 076 - Agassiz-Harrison	1.5%	0.4%	5.4%	7.7%	4.2%	13.6%	12.4%	7.8%	19.2%	11.5%	7.1%	18.2%	10.4%	6.3%	16.8%
LHA 075 - Mission	3.4%	2.3%	5.2%	4.7%	3.3%	6.7%	5.7%	4.1%	7.8%	7.1%	5.3%	9.4%	7.6%	5.8%	9.9%
LHA 043 - Coquitlam	3.9%	3.2%	4.7%	6.1%	5.3%	7.1%	5.6%	4.8%	6.5%	8.7%	7.7%	9.9%	10.0%	9.0%	11.3%
LHA 042 - Maple Ridge	3.4%	2.5%	4.6%	4.4%	3.4%	5.8%	3.6%	2.6%	4.8%	6.0%	4.8%	7.5%	5.6%	4.5%	7.1%
LHA 041 - Burnaby	4.4%	3.8%	5.1%	6.5%	5.8%	7.4%	7.2%	6.4%	8.1%	11.6%	10.6%	12.6%	11.3%	10.3%	12.4%
LHA 040 - New Westminster	3.0%	2.1%	4.2%	5.0%	3.9%	6.5%	6.5%	5.2%	8.2%	9.2%	7.7%	11.1%	10.3%	8.7%	12.3%
LHA 037 - Delta	3.4%	2.6%	4.4%	5.5%	4.5%	6.7%	6.1%	5.0%	7.4%	10.3%	8.9%	11.9%	9.7%	8.3%	11.3%
LHA 035 - Langley	5.7%	4.7%	6.9%	7.5%	6.4%	8.8%	9.3%	8.1%	10.8%	11.7%	10.3%	13.3%	11.5%	10.1%	13.0%
LHA 034 - Abbotsford	3.2%	2.5%	4.0%	4.9%	4.1%	5.9%	6.0%	5.1%	7.1%	6.5%	5.6%	7.7%	6.6%	5.7%	7.8%
LHA 033 - Chilliwack	2.1%	1.5%	3.1%	5.8%	4.6%	7.2%	8.8%	7.3%	10.5%	10.1%	8.5%	11.9%	10.2%	8.7%	12.1%
LHA 032 - Hope	5.5%	2.8%	10.4%	8.6%	5.1%	14.2%	8.7%	5.1%	14.3%	6.7%	3.7%	11.8%	10.4%	6.5%	16.2%

None of the Five Recommended Procedures

Information on the proportion of adults with diagnosed type 2 diabetes who received none of the five recommended each fiscal year is provided in table C-7. The proportion of adults with diagnosed type 2 diabetes who received none of the five procedures per fiscal year decreased from 3.0% in 1996/97 to 2.2% in 2000/01. The difference between these two proportions is significant (McNemar test, Chi-square = 31, $p<.001$).

The largest reduction in the proportion of adults with diagnosed type 2 diabetes who received none of the five procedures per fiscal year occurred between 1996/97 and 1997/98 (from 3.3% to 1.8%; McNemar test, Chi-square = 75, p<.001). After that year, no significant reductions in this proportion were observed. Indeed, between 1999/00 and 2000/01, a significant *increase* in this proportion was observed (from 1.8% to 2.2%; McNemar test, Chi-square = 12, p<.001).

Table C-7 Proportion of Adults with Diagnosed Type 2 Diabetes
Receiving None of the Five Recommended Services

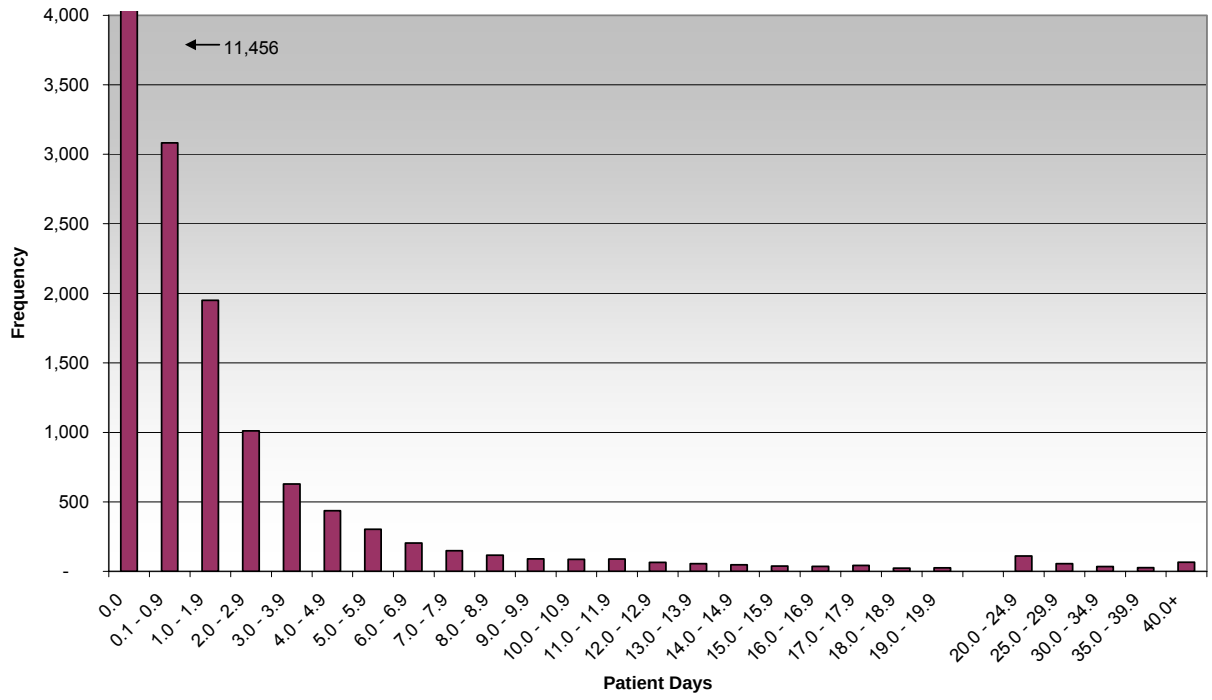
	1996/97			1997/98			1998/99			1999/00			2000/01		
	%	95% CI		%	95% CI		%	95% CI		%	95% CI		%	95% CI	
Total Population	3.1%	2.9%	3.4%	1.9%	1.8%	2.1%	1.8%	1.6%	2.0%	2.0%	1.8%	2.2%	2.4%	2.2%	2.6%
By Sex															
Female	2.8%	2.5%	3.1%	1.6%	1.4%	1.9%	1.8%	1.5%	2.0%	1.9%	1.7%	2.2%	2.3%	2.0%	2.6%
Male	3.4%	3.1%	3.8%	2.2%	1.9%	2.5%	1.8%	1.6%	2.1%	2.0%	1.8%	2.2%	2.5%	2.2%	2.8%
By Age															
20-29	7.2%	5.1%	10.1%	5.1%	3.2%	7.9%	5.5%	3.4%	8.8%	6.7%	4.2%	10.6%	7.9%	4.9%	12.7%
30-39	5.8%	4.7%	7.2%	3.9%	3.0%	5.2%	3.7%	2.7%	5.0%	5.4%	4.1%	6.9%	4.8%	3.6%	6.4%
40-49	4.3%	3.7%	5.0%	2.2%	1.8%	2.8%	2.4%	1.9%	3.1%	3.3%	2.6%	4.0%	3.8%	3.1%	4.7%
50-59	2.9%	2.5%	3.4%	1.7%	1.4%	2.1%	1.9%	1.5%	2.3%	1.6%	1.3%	2.0%	2.6%	2.1%	3.0%
60-69	2.2%	1.9%	2.6%	1.4%	1.1%	1.7%	1.0%	0.8%	1.3%	1.0%	0.8%	1.3%	1.2%	1.0%	1.5%
70-79	2.4%	2.0%	2.9%	1.7%	1.4%	2.1%	1.5%	1.2%	1.9%	1.6%	1.3%	1.9%	1.9%	1.6%	2.3%
80+	4.3%	3.2%	5.7%	3.1%	2.3%	4.2%	2.6%	1.9%	3.5%	3.1%	2.4%	4.0%	3.6%	2.9%	4.5%
By Socio-Economic Status															
Quintile 1 (Low)	2.9%	2.4%	3.4%	1.7%	1.4%	2.1%	1.6%	1.2%	2.0%	1.9%	1.6%	2.3%	2.2%	1.8%	2.6%
Quintile 2	3.0%	2.6%	3.5%	1.6%	1.3%	2.0%	2.0%	1.6%	2.4%	1.9%	1.5%	2.3%	2.6%	2.2%	3.1%
Quintile 3	3.2%	2.8%	3.8%	2.2%	1.8%	2.6%	1.8%	1.5%	2.2%	1.8%	1.4%	2.2%	2.1%	1.8%	2.6%
Quintile 4	3.1%	2.6%	3.7%	2.2%	1.8%	2.7%	1.9%	1.6%	2.4%	2.2%	1.8%	2.7%	2.5%	2.0%	3.0%
Quintile 5 (High)	3.7%	3.1%	4.5%	2.0%	1.6%	2.6%	1.7%	1.3%	2.3%	2.1%	1.6%	2.7%	2.7%	2.2%	3.4%
By Morbidity															
Very Low	8.0%	5.6%	11.3%	9.4%	6.8%	12.9%	10.3%	7.5%	13.9%	13.1%	10.0%	17.0%	8.8%	6.3%	12.3%
Low	7.4%	6.4%	8.5%	4.9%	4.1%	5.9%	6.1%	5.2%	7.2%	6.0%	5.1%	7.0%	5.9%	5.1%	7.0%
Medium	4.2%	3.7%	4.9%	2.6%	2.1%	3.0%	2.5%	2.1%	3.0%	2.4%	2.0%	2.9%	3.1%	2.6%	3.6%
High	2.8%	2.4%	3.1%	1.5%	1.3%	1.8%	1.1%	0.9%	1.3%	1.3%	1.0%	1.5%	1.9%	1.6%	2.2%
Very High	1.1%	0.9%	1.4%	0.6%	0.4%	0.8%	0.3%	0.2%	0.5%	0.3%	0.2%	0.5%	0.9%	0.7%	1.1%
By Disease-Specific Severity Index															
No Complications	5.5%	5.0%	6.0%	3.7%	3.3%	4.2%	3.8%	3.4%	4.3%	4.3%	3.8%	4.8%	4.4%	3.9%	4.9%
1 or More Minor Complications	2.1%	1.8%	2.5%	1.0%	0.8%	1.3%	1.0%	0.8%	1.2%	0.9%	0.7%	1.2%	1.5%	1.3%	1.8%
1 or More Intermediate Complications	2.0%	1.7%	2.4%	1.2%	1.0%	1.5%	0.7%	0.6%	1.0%	0.8%	0.6%	1.1%	1.5%	1.2%	1.8%
1 Major Complication	3.9%	2.5%	6.2%	3.2%	1.9%	5.4%	2.5%	1.4%	4.5%	2.1%	1.1%	3.9%	3.0%	1.8%	5.1%
2 or More Major Complications	1.5%	0.8%	2.9%	0.3%	0.1%	1.2%	1.0%	0.5%	2.2%	1.7%	0.9%	3.1%	1.4%	0.7%	2.6%
By Patient Residence															
LHA 202 - S. Surrey / White Rock	3.6%	2.7%	4.8%	1.2%	0.7%	1.9%	1.6%	1.1%	2.5%	2.0%	1.4%	3.0%	2.0%	1.4%	3.0%
LHA 201 - Surrey	2.8%	2.4%	3.3%	1.7%	1.4%	2.1%	1.6%	1.3%	2.0%	1.8%	1.4%	2.2%	2.5%	2.1%	2.9%
LHA 076 - Agassiz-Harrison	3.1%	1.2%	7.6%	1.5%	0.4%	5.4%	1.6%	0.4%	5.5%	1.5%	0.4%	5.4%	0.7%	0.1%	4.1%
LHA 075 - Mission	5.4%	3.9%	7.5%	2.8%	1.7%	4.4%	2.1%	1.2%	3.6%	3.8%	2.5%	5.6%	2.4%	1.5%	4.0%
LHA 043 - Coquitlam	3.6%	3.0%	4.4%	2.4%	1.9%	3.0%	1.7%	1.3%	2.3%	2.1%	1.6%	2.7%	2.5%	2.0%	3.2%
LHA 042 - Maple Ridge	2.7%	1.9%	3.8%	2.0%	1.4%	3.0%	2.0%	1.4%	3.0%	1.8%	1.2%	2.7%	2.1%	1.4%	3.0%
LHA 041 - Burnaby	2.6%	2.2%	3.2%	1.6%	1.3%	2.1%	1.6%	1.2%	2.0%	1.5%	1.2%	2.0%	1.9%	1.5%	2.4%
LHA 040 - New Westminster	2.9%	2.0%	4.1%	2.2%	1.5%	3.3%	1.7%	1.1%	2.6%	2.2%	1.5%	3.3%	3.0%	2.2%	4.2%
LHA 037 - Delta	2.8%	2.1%	3.7%	2.0%	1.4%	2.8%	2.0%	1.4%	2.8%	2.7%	2.0%	3.6%	3.4%	2.6%	4.4%
LHA 035 - Langley	2.8%	2.1%	3.6%	2.6%	1.9%	3.4%	1.7%	1.2%	2.4%	2.2%	1.6%	3.0%	2.8%	2.1%	3.6%
LHA 034 - Abbotsford	3.3%	2.6%	4.2%	2.0%	1.5%	2.7%	2.9%	2.3%	3.7%	1.8%	1.3%	2.4%	2.5%	1.9%	3.2%
LHA 033 - Chilliwack	4.8%	3.7%	6.2%	1.6%	1.0%	2.5%	1.5%	1.0%	2.4%	2.0%	1.3%	2.9%	1.7%	1.1%	2.6%
LHA 032 - Hope	4.8%	2.3%	9.6%	2.6%	1.0%	6.6%	2.7%	1.0%	6.7%	1.3%	0.4%	4.7%	3.9%	1.8%	8.2%

Appendix D: Description of Individual Resource Use Variables

Acute Care Patient Days

The frequency distribution for the mean annual utilization of acute care days over the five year period is shown in Figure D-1. Of the 20,228 subjects in the study, 11,456 (56.7%) did not use any acute care days over the entire five year study period. The range was from 0 to 88.8 acute care days.

Figure D-1 Frequency Distribution for
Average Annual Acute Care Inpatient Days



Information on the utilization of acute care days on a year by year basis by adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority is provided in table D-1. Mean utilization of acute care days increased from 1.25 (95% CI; 1.16, 1.35) per person in 1996/97 to 2.13 (95% CI; 1.98, 2.31) in 2000/01. During the five year period, an average of 1.62 (95% CI; 1.56, 1.69) acute care days were utilized per person per year.

Table D-1 Adults with Diagnosed Diabetes
Utilization of Acute Care Days

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Total Population	1.25	1.16	1.35	1.46	1.35	1.56	1.50	1.39	1.61	1.77	1.64	1.90	2.13	1.97	2.29	1.62	1.56	1.69
By Sex																		
Female	1.42	1.25	1.58	1.57	1.41	1.73	1.55	1.39	1.71	1.94	1.74	2.14	2.37	2.10	2.63	1.77	1.66	1.87
Male	1.11	1.00	1.21	1.35	1.22	1.48	1.45	1.30	1.60	1.63	1.46	1.80	1.93	1.74	2.13	1.49	1.41	1.58
By Age																		
30-39	1.06	0.74	1.38	0.88	0.64	1.11	0.95	0.61	1.28	0.96	0.62	1.31	1.32	0.51	2.12	1.00	0.75	1.25
40-49	0.69	0.54	0.84	1.04	0.76	1.32	0.82	0.64	1.01	0.87	0.66	1.07	0.93	0.67	1.20	0.90	0.76	1.04
50-59	0.93	0.77	1.08	1.07	0.90	1.24	0.97	0.82	1.13	1.01	0.86	1.16	1.14	0.96	1.31	1.05	0.96	1.15
60-69	1.33	1.16	1.50	1.46	1.28	1.64	1.41	1.23	1.60	1.76	1.51	2.00	1.90	1.61	2.19	1.55	1.43	1.66
70-79	2.13	1.82	2.43	2.35	2.07	2.62	2.61	2.29	2.92	2.81	2.50	3.13	3.58	3.16	4.00	2.81	2.63	2.98
By Socio-Economic Status																		
Quintile 1 (Low)	1.48	1.23	1.72	1.74	1.50	1.98	1.92	1.62	2.23	2.30	1.95	2.65	2.72	2.31	3.14	2.00	1.83	2.17
Quintile 2	1.26	1.06	1.46	1.36	1.15	1.56	1.42	1.19	1.65	1.79	1.50	2.09	2.31	1.96	2.65	1.63	1.49	1.77
Quintile 3	1.19	1.00	1.38	1.34	1.10	1.58	1.30	1.09	1.51	1.79	1.52	2.05	1.97	1.63	2.37	1.38	1.26	1.50
Quintile 4	1.19	0.96	1.41	1.37	1.16	1.59	1.41	1.18	1.64	1.45	1.21	1.69	1.80	1.45	2.16	1.52	1.38	1.67
Quintile 5 (High)	1.00	0.80	1.21	1.30	1.03	1.57	1.35	1.11	1.60	1.34	1.05	1.63	1.67	1.30	2.04	1.44	1.27	1.60
By Morbidity																		
Very Low	0.29	0.12	0.46	0.12	0.03	0.21	0.02	(0.02)	0.06	0.07	(0.06)	0.20	0.19	0.06	0.33	0.14	0.08	0.19
Low	0.45	0.29	0.62	0.40	0.25	0.55	0.03	0.01	0.05	0.02	0.01	0.03	0.63	0.36	0.89	0.31	0.24	0.38
Medium	0.68	0.53	0.83	0.64	0.49	0.79	0.12	0.09	0.14	0.16	0.13	0.20	0.81	0.64	0.97	0.48	0.42	0.54
High	1.08	0.95	1.21	1.32	1.16	1.47	0.90	0.78	1.01	1.05	0.89	1.22	2.06	1.79	2.33	1.28	1.19	1.37
Very High	2.32	2.06	2.58	2.79	2.52	3.07	4.04	3.69	4.39	4.77	4.37	5.18	4.02	3.59	4.44	3.59	3.40	3.78
By Disease-Specific Severity Index																		
No Complications	0.91	0.76	1.06	0.83	0.70	0.96	0.57	0.45	0.69	0.61	0.49	0.74	1.12	0.93	1.30	0.81	0.73	0.89
1 or More Minor Complications	1.13	0.97	1.29	1.35	1.20	1.51	1.34	1.12	1.51	1.36	1.19	1.52	1.75	1.51	1.99	1.39	1.29	1.48
1 or More Intermediate Complications	1.47	1.30	1.64	1.90	1.66	2.13	2.03	1.81	2.25	2.73	2.42	3.04	3.09	2.74	3.44	2.24	2.10	2.38
1 Major Complication	3.32	2.07	4.58	3.56	2.25	4.87	4.50	3.08	5.92	6.15	4.39	7.92	5.43	3.50	7.35	4.59	3.70	5.49
2 or More Major Complications	4.53	2.80	6.26	5.75	4.41	7.37	10.74	8.13	13.34	11.43	8.49	14.37	9.09	5.20	12.98	8.31	6.84	9.78
By Patient Residence																		
LHA 202 - S. Surrey / WR	1.05	0.79	1.32	1.26	0.92	1.60	1.20	0.90	1.51	1.75	1.28	2.22	2.73	1.98	3.49	1.62	1.38	1.86
LHA 201 - Surrey	1.34	1.14	1.54	1.49	1.25	1.72	1.60	1.32	1.87	1.74	1.45	2.03	1.87	1.52	2.22	1.61	1.46	1.76
LHA 076 - Agassiz-Harrison	3.33	(0.08)	6.75	1.77	0.73	2.81	1.27	0.54	2.00	1.11	(0.15)	2.37	3.23	0.25	6.22	2.15	0.94	3.36
LHA 075 - Mission	1.40	0.85	1.96	1.99	0.94	3.05	1.62	1.09	2.14	1.48	0.88	2.09	1.66	1.05	2.27	1.69	1.29	2.08
LHA 043 - Coquitlam	1.26	0.97	1.54	1.61	1.27	1.95	1.57	1.21	1.93	1.72	1.33	2.11	2.34	1.80	2.88	1.67	1.46	1.88
LHA 042 - Maple Ridge	1.15	0.82	1.48	1.34	0.96	1.72	1.85	1.39	2.30	1.67	1.23	2.12	1.92	1.34	2.51	1.59	1.35	1.83
LHA 041 - Burnaby	1.00	0.80	1.19	1.12	0.94	1.30	1.07	0.85	1.29	1.59	1.24	1.94	1.64	1.30	1.98	1.31	1.17	1.45
LHA 040 - New Westminster	2.08	1.19	2.97	2.12	1.33	2.91	2.26	1.55	2.97	2.85	2.03	3.68	2.79	2.01	3.57	2.30	1.88	2.73
LHA 037 - Delta	0.96	0.70	1.21	1.35	1.03	1.68	1.11	0.85	1.37	1.47	1.03	1.90	1.63	1.19	2.06	1.30	1.10	1.49
LHA 035 - Langley	1.44	1.07	1.81	1.25	0.99	1.50	1.62	1.27	1.97	2.01	1.50	2.52	2.66	1.90	3.42	1.81	1.27	1.97
LHA 034 - Abbotsford	1.20	0.95	1.45	1.67	1.36	1.98	1.51	1.23	1.79	1.55	1.26	1.83	2.50	2.00	2.99	1.67	1.48	1.85
LHA 033 - Chilliwack	1.08	0.84	1.33	1.53	1.14	1.92	1.47	1.10	1.85	2.34	1.75	2.92	2.58	1.89	3.27	1.82	1.54	2.10
LHA 032 - Hope	1.64	0.81	2.47	1.17	0.30	2.05	3.65	1.75	5.54	2.60	1.25	3.95	3.27	1.76	4.78	2.45	1.68	3.22

Information on the utilization of acute care costs as a binary variable is indicated on table D-2. Based on this information, adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority who are in the low adherence group are less likely to be in the high utilization of acute care costs group (17.1%; 95% CI 16.1%, 18.2%) compared to individuals in the medium or high adherence groups (20.0%; 95% CI 19.3%, 20.9% and 20.9%; 95% CI 19.8%, 21.9%).

While there is no significant difference between females and males, there appears to be a clear trend based on age, with older individuals more likely to be in the high utilization of acute care costs category than younger individuals. Similar trends are apparent for both morbidity and disease-specific severity index variables, with individuals in the lower morbidity and severity

groups less likely to be in the high utilization category than individuals in the higher morbidity and severity groups.

Table D-2 Proportion of Adults with Diagnosed Diabetes
High Utilization of Average Annual Acute Care Dollars

	Total N in Year 3	N	%	95% CI	
Total Population	20,228	4,040	20.0%	19.5%	20.6%
By Level of Adherence					
Low	5,136	880	17.1%	16.1%	18.2%
Medium	9,448	1,894	20.0%	19.3%	20.9%
Hiigh	5,644	1,177	20.9%	19.8%	21.9%
By Sex					
Female	9,256	1,819	19.7%	18.9%	20.5%
Male	10,917	2,211	20.3%	19.5%	21.0%
By Age *(in Year 3)*					
30-39	1,081	109	10.1%	8.6%	12.2%
40-49	2,795	279	10.0%	9.0%	11.2%
50-59	5,054	726	14.4%	13.4%	15.4%
60-69	6,205	1,274	20.5%	19.6%	21.6%
70-79	5,093	1,653	32.5%	31.2%	33.8%
By Socio-Economic Status *(in Year 3)*					
Quintile 1 (Low)	4,026	899	22.3%	21.1%	23.7%
Quintile 2	4,330	880	20.3%	19.1%	21.5%
Quintile 3	4,638	844	18.2%	17.2%	19.4%
Quintile 4	4,121	801	19.4%	18.3%	20.7%
Quintile 5 (High)	2,706	515	19.0%	17.6%	20.5%
By Morbidity					
Very Low	334	8	2.4%	1.2%	4.7%
Low	2,186	89	4.1%	3.3%	5.0%
Medium	4,500	281	6.2%	5.6%	7.0%
High	7,449	1,322	17.7%	16.9%	18.6%
Very High	5,622	2,324	41.3%	40.1%	42.7%
By Disease-Specific Severity Index					
No Complications	6,366	635	10.0%	9.3%	10.8%
1 or More Minor Complications	6,951	1,291	18.6%	17.7%	19.5%
1 or More Intermediate Complications	6,289	1,769	28.1%	27.1%	29.3%
1 Major Complication	338	150	44.4%	39.2%	49.7%
2 or More Major Complications	284	196	69.0%	63.5%	74.2%
By Patient Residence *(in Year 3)*					
LHA 202 - S. Surrey / WR	1,035	234	22.6%	20.2%	25.3%
LHA 201 - Surrey	4,861	871	17.9%	16.9%	19.0%
LHA 076 - Agassiz-Harrison	123	29	23.6%	17.0%	31.8%
LHA 075 - Mission	560	119	21.3%	18.2%	25.0%
LHA 043 - Coquitlam	2,434	257	10.6%	17.3%	20.4%
LHA 042 - Maple Ridge	1,056	236	22.3%	19.9%	25.0%
LHA 041 - Burnaby	3,253	538	16.5%	15.3%	17.9%
LHA 040 - New Westminster	903	215	23.8%	21.2%	26.7%
LHA 037 - Delta	1,404	266	18.9%	16.7%	21.1%
LHA 035 - Langley	1,564	360	23.0%	21.1%	25.2%
LHA 034 - Abbotsford	1,837	421	22.9%	21.1%	25.0%
LHA 033 - Chilliwack	1,065	252	23.7%	21.3%	26.4%
LHA 032 - Hope	133	43	32.3%	25.0%	40.7%

Results based on the socio-economic status (SES) of the individual are more mixed. Adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health

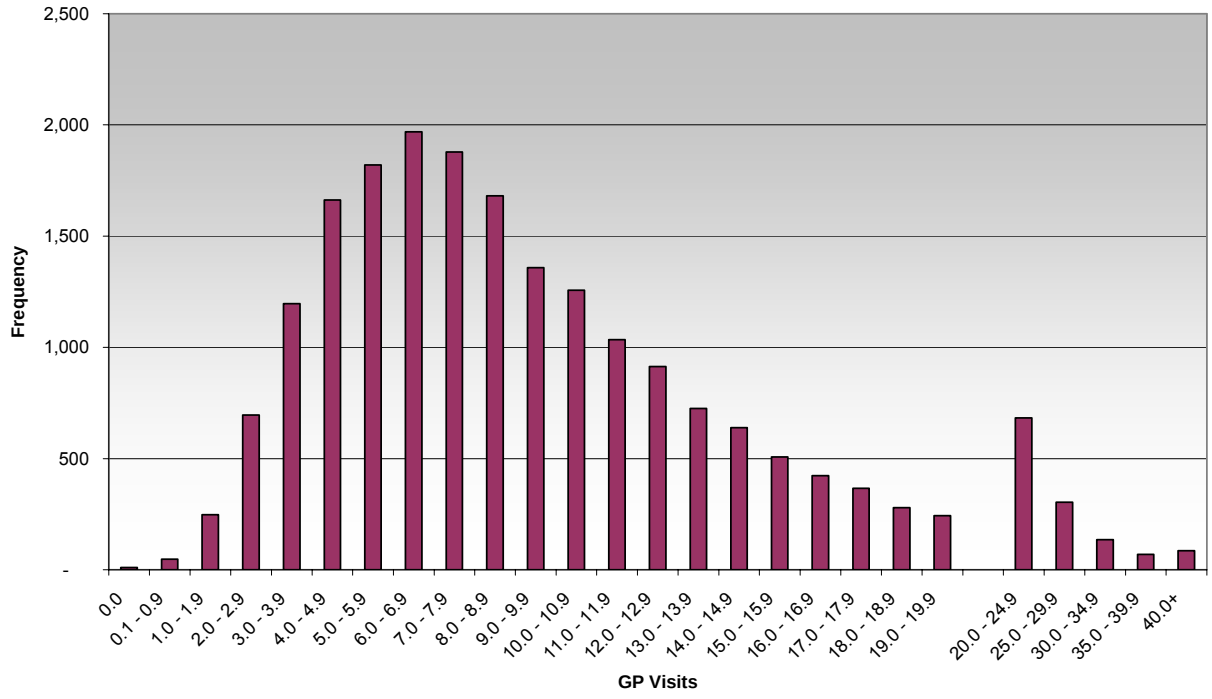
Authority in the lowest socio-economic status category are more likely to be in the high utilization category than those in median and higher SES quintiles (quintiles 3, 4 and 5).

The proportion of adults with diagnosed type 2 diabetes in the high utilization of acute care costs category by local health area (LHA) ranges from 16.5% (95% CI; 15.3%, 17.9%) in the LHA of Burnaby to 32.3% (95% CI; 25.0%; 40.7%) in the LHA of Hope.

General Practitioner Visits

The frequency distribution for the mean annual utilization of general practitioner (GP) visits over the five year period is shown in Figure D-2. Of the 20,228 subjects in the study, 10 (0.05%) did not use any GP visits over the entire five year study period. The mean utilization was 9.78 visits per person per year (median of 8.2, range from 0 to 70.2 GP visits).

Figure D-2 Frequency Distribution for
Average Annual General Practitioner Visits



Information on the utilization of general practitioner visits on a year by year basis by adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health

Authority is provided in table D-3. Mean utilization of GP visits increased from 9.06 (95% CI; 8.95, 9.16) per person in 1996/97 to 10.11 (95% CI; 10.00, 10.23) in 2000/01. During the five year period, an average of 9.74 (95% CI; 9.65, 9.83) GP visits were utilized per person per year.

Table D-3 Adults with Diagnosed Diabetes
Utilization of General Practitioner Visits

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Total Population	9.06	8.95	9.16	9.84	9.73	9.94	9.63	9.53	9.73	10.06	9.96	10.17	10.11	10.00	10.23	9.74	9.65	9.83
By Sex																		
Female	10.01	9.85	10.17	10.82	10.66	10.99	10.48	10.32	10.64	10.87	10.71	11.03	10.89	10.72	11.06	10.62	10.48	10.75
Male	8.25	8.12	8.39	9.00	8.86	9.14	8.92	8.78	9.05	9.38	9.24	9.52	9.46	9.31	9.61	9.00	8.89	9.12
By Age																		
30-39	9.08	8.56	9.59	9.76	9.26	10.26	9.12	8.61	9.63	8.98	8.43	9.53	8.69	8.13	9.26	9.29	8.85	9.74
40-49	8.62	8.35	8.90	9.28	8.98	9.59	8.94	8.64	9.23	9.50	9.18	9.82	9.45	9.08	9.81	9.11	8.85	9.37
50-59	8.67	8.47	8.87	9.46	9.25	9.67	9.29	9.08	9.49	9.58	9.36	9.79	9.56	9.34	9.79	9.33	9.16	9.51
60-69	9.16	8.99	9.32	9.72	9.54	9.89	9.48	9.31	9.65	10.03	9.85	10.21	9.97	9.78	10.16	9.65	9.50	9.79
70-79	9.81	9.59	10.03	10.85	10.63	11.07	10.64	10.42	10.85	10.94	10.73	11.15	10.99	10.78	11.21	10.70	10.54	10.87
By Socio-Economic Status																		
Quintile 1 (Low)	10.36	10.10	10.62	11.27	11.01	11.54	11.08	10.82	11.34	11.36	11.11	11.62	11.47	11.21	11.73	11.14	10.92	11.37
Quintile 2	9.56	9.32	9.80	10.16	9.92	10.39	10.02	9.80	10.25	10.46	10.22	10.70	10.57	10.32	10.82	10.13	9.94	10.31
Quintile 3	9.05	8.83	9.27	9.72	9.50	9.94	9.52	9.31	9.73	9.93	9.71	10.15	9.95	9.72	10.18	9.62	9.44	9.80
Quintile 4	8.22	8.01	8.43	9.09	8.87	9.32	8.80	8.60	9.01	9.31	9.09	9.52	9.22	8.99	9.44	8.94	8.77	9.12
Quintile 5 (High)	7.66	7.40	7.91	8.44	8.18	8.69	8.23	7.98	8.47	8.64	8.38	8.90	8.70	8.41	8.98	8.34	8.14	8.53
By Morbidity																		
Very Low	4.43	4.05	4.82	4.67	4.29	5.05	3.43	3.17	3.69	3.39	3.12	3.66	4.57	4.20	4.93	4.10	3.87	4.33
Low	5.40	5.21	5.58	5.78	5.61	5.95	4.36	4.23	4.49	4.56	4.43	4.69	5.65	5.47	5.84	5.15	5.04	5.26
Medium	6.65	6.51	6.80	7.22	7.07	7.36	6.42	6.30	6.54	6.76	6.63	6.88	7.38	7.22	7.53	6.88	6.78	6.99
High	8.55	8.41	8.69	9.23	9.09	9.37	8.87	8.75	8.99	9.37	9.25	9.49	9.66	9.51	9.82	9.14	9.04	9.24
Very High	13.32	13.06	13.57	14.57	14.31	14.83	15.57	15.32	15.82	16.11	15.86	16.36	14.96	14.69	15.22	14.90	14.70	15.11
By Disease-Specific Severity Index																		
No Complications	7.27	7.11	7.42	7.80	7.64	7.96	7.20	7.05	7.34	7.57	7.42	7.72	8.03	7.87	8.20	7.57	7.45	7.70
1 or More Minor Complications	9.46	9.29	9.64	10.36	10.17	10.54	10.13	9.95	10.30	10.59	10.41	10.76	10.49	10.31	10.68	10.21	10.06	10.35
1 or More Intermediate Complications	10.19	9.99	10.38	11.08	10.87	11.28	11.19	10.99	11.39	11.62	11.41	11.83	11.49	11.28	11.70	11.11	10.95	11.28
1 Major Complication	10.38	9.26	11.51	11.41	10.41	12.41	11.52	10.58	12.46	12.59	11.59	13.58	12.43	11.27	13.60	11.67	10.81	12.52
2 or More Major Complications	12.60	11.42	13.78	13.42	12.19	14.66	15.18	13.77	16.58	15.63	14.24	17.02	14.24	12.70	15.79	14.21	13.18	15.24
By Patient Residence																		
LHA 202 - S. Surrey / WR	7.82	7.41	8.23	8.60	8.13	9.06	8.60	8.17	9.03	9.57	9.07	10.07	9.83	9.32	10.33	8.95	8.58	9.32
LHA 201 - Surrey	10.19	9.95	10.42	10.89	10.66	11.13	10.66	10.43	10.89	11.15	10.91	11.39	11.06	10.82	11.30	10.77	10.58	10.97
LHA 076 - Agassiz-Harrison	9.69	7.92	11.46	10.13	8.79	11.47	9.82	8.48	11.16	10.26	8.66	11.85	10.41	8.97	11.85	9.80	8.56	11.04
LHA 075 - Mission	9.19	8.57	9.81	10.69	9.94	11.44	10.32	9.67	10.97	10.89	10.17	11.61	11.02	10.28	11.75	10.56	9.96	11.15
LHA 043 - Coquitlam	8.16	7.90	8.42	8.98	8.70	9.26	8.65	8.38	8.91	8.85	8.59	9.10	9.00	8.73	9.28	8.74	8.52	8.96
LHA 042 - Maple Ridge	9.18	8.74	9.62	9.99	9.53	10.44	9.83	9.39	10.27	10.42	9.98	10.86	10.56	10.08	11.03	10.05	9.68	10.42
LHA 041 - Burnaby	8.60	8.38	8.82	9.31	9.08	9.54	9.02	8.79	9.26	9.56	9.31	9.81	9.67	9.40	9.94	9.21	9.01	9.41
LHA 040 - New Westminster	8.62	8.19	9.05	9.41	8.97	9.85	9.34	8.91	9.77	9.97	9.51	10.43	9.56	9.11	10.00	9.39	9.02	9.77
LHA 037 - Delta	9.32	8.91	9.73	9.92	9.47	10.38	9.45	9.04	9.87	9.72	9.32	10.11	10.01	9.57	10.45	9.65	9.30	10.00
LHA 035 - Langley	8.41	8.06	8.76	9.13	8.77	9.49	9.09	8.72	9.45	9.11	8.76	9.46	8.59	8.23	8.96	8.86	8.58	9.14
LHA 034 - Abbotsford	9.49	9.14	9.83	10.26	9.92	10.60	9.96	9.62	10.29	10.29	9.95	10.63	10.68	10.31	11.04	10.11	9.83	10.39
LHA 033 - Chilliwack	8.44	7.99	8.89	9.59	9.14	10.05	9.74	9.27	10.20	10.27	9.79	10.75	10.26	9.79	10.73	9.71	9.31	10.10
LHA 032 - Hope	10.35	8.92	11.77	11.05	9.46	12.65	13.06	11.08	15.04	12.59	10.98	14.21	14.47	12.33	16.61	12.32	10.88	13.75

Information on the utilization of GP costs as a binary variable is indicated on table D-4. Based on this information, adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority who are in the low adherence group are less likely to be in the high utilization of GP costs category (14.5%; 95% CI 13.6%, 15.5%) compared to individuals in the medium or high adherence groups (20.5%; 95% CI 19.7%, 21.3% and 23.9%; 95% CI 12.8%, 25.1%).

Table D-4 Proportion of Adults with Diagnosed Diabetes
High Utilization of Average Annual General Practitioner Dollars

	Total N in Year 3	N	%	95% CI	
Total Population	20,228	4,034	19.9%	19.4%	20.5%
By Level of Adherence					
Low	5,136	747	14.5%	13.6%	15.5%
Medium	9,448	1,937	20.5%	19.7%	21.3%
High	5,644	1,350	23.9%	22.8%	25.1%
By Sex					
Female	9,256	2,198	23.7%	22.9%	24.7%
Male	10,917	1,829	16.8%	16.1%	17.5%
By Age *(in Year 3)*					
30-39	1,081	196	18.1%	16.0%	20.6%
40-49	2,795	457	16.4%	15.0%	17.8%
50-59	5,054	840	16.6%	15.7%	17.7%
60-69	6,205	1,096	17.7%	16.7%	18.6%
70-79	5,093	1,445	28.4%	27.2%	29.6%
By Socio-Economic Status *(in Year 3)*					
Quintile 1 (Low)	4,026	1,104	27.4%	26.1%	28.8%
Quintile 2	4,330	914	21.1%	19.9%	22.4%
Quintile 3	4,638	877	18.9%	17.8%	20.1%
Quintile 4	4,121	680	16.5%	15.4%	17.7%
Quintile 5 (High)	2,706	361	13.3%	12.1%	14.7%
By Morbidity					
Very Low	334	-	0.0%		
Low	2,186	26	1.2%	0.8%	1.7%
Medium	4,500	193	4.3%	3.7%	4.9%
High	7,449	1,000	13.4%	12.7%	14.2%
Very High	5,622	2,778	49.4%	48.1%	50.8%
By Disease-Specific Severity Index					
No Complications	6,366	659	10.4%	9.6%	11.1%
1 or More Minor Complications	6,951	1,397	20.1%	19.2%	21.1%
1 or More Intermediate Complications	6,289	1,731	27.5%	26.5%	28.7%
1 Major Complication	338	110	32.5%	27.8%	37.7%
2 or More Major Complications	284	137	48.2%	42.7%	54.2%
By Patient Residence *(in Year 3)*					
LHA 202 - S. Surrey / WR	1,035	177	17.1%	14.9%	19.5%
LHA 201 - Surrey	4,861	1,162	23.9%	22.7%	25.1%
LHA 076 - Agassiz-Harrison	123	23	18.7%	12.8%	26.5%
LHA 075 - Mission	560	129	23.0%	19.9%	26.8%
LHA 043 - Coquitlam	2,434	364	15.0%	13.6%	16.5%
LHA 042 - Maple Ridge	1,056	241	22.8%	20.4%	25.5%
LHA 041 - Burnaby	3,253	553	17.0%	15.8%	18.4%
LHA 040 - New Westminster	903	183	20.3%	17.8%	23.0%
LHA 037 - Delta	1,404	273	19.4%	17.5%	21.6%
LHA 035 - Langley	1,564	250	16.0%	14.3%	17.9%
LHA 034 - Abbotsford	1,837	414	22.5%	20.7%	24.5%
LHA 033 - Chilliwack	1,065	217	20.4%	18.1%	22.9%
LHA 032 - Hope	133	48	36.1%	28.4%	44.5%

Males are significantly less likely to be in the high utilization category (16.8%; 95% CI 16.1%, 17.5%) compared to females (23.7%; 95% CI 22.9%, 24.7%).

Individuals aged 70-79 (28.4%; 95% CI 27.2%, 29.6%) are more likely to be in the high utilization category than any other age group.

There appears to be a clear trend based on socio-economic status (SES), with individuals in the low SES (quintile 1) category more likely to be in the high utilization category (27.4%; 95% CI 26.1%, 28.8%) than individuals in the high SES (quintile 5) category (13.3%; 95% CI 12.1%, 14.7%).

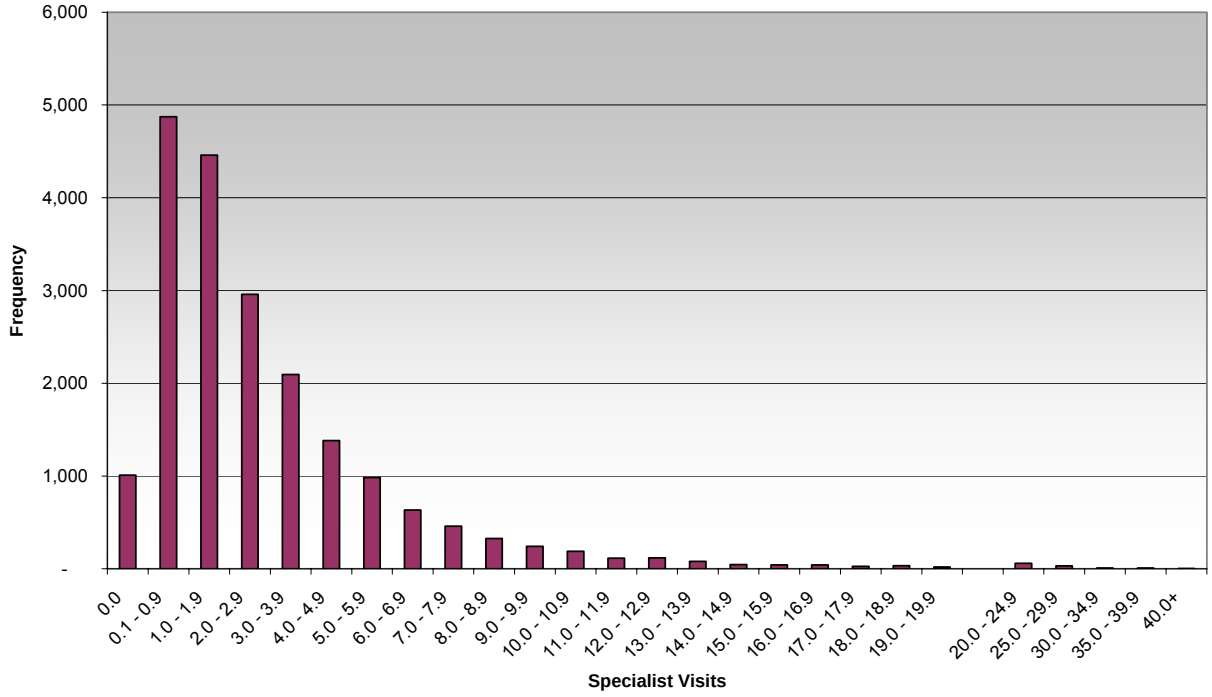
Similar trends are apparent for both morbidity and disease-specific severity index variables, with individuals in the lower morbidity and severity groups less likely to be in the high utilization category than individuals in the higher morbidity and severity groups.

The proportion of adults with diagnosed type 2 diabetes in the high utilization of GP cost category by local health area (LHA) ranges from 15.0% (95% CI; 13.6%, 16.5%) in the LHA of Coquitlam to 36.1% (95% CI; 28.4%; 44.5%) in the LHA of Hope.

Specialist Physician Visits

The frequency distribution for the mean annual utilization of specialist physician visits over the five year period is shown in Figure D-3. Of the 20,228 subjects in the study, 1,008 (4.98%) did not use any specialist physician visits over the entire five year study period. The mean utilization was 2.88 visits per person per year (median of 1.8, range from 0 to 41.6 visits).

Figure D-3 Frequency Distribution for
Average Annual Specialist Physician Visits



Information on the utilization of specialist physician visits on a year by year basis by adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority is provided in table D-. Mean utilization of specialist physicians increased from 2.55 (95% CI; 2.49, 2.61) per person in 1996/97 to 3.10 (95% CI; 3.03, 3.17) in 2000/01. During the five year period, an average of 2.88 (95% CI; 2.83, 2.92) specialist physician visits were utilized per person per year.

Table D-5 Adults with Diagnosed Diabetes
Utilization of Specialist Physician Visits

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Total Population	2.55	2.49	2.61	2.87	2.81	2.94	2.85	2.79	2.92	3.00	2.93	3.06	3.10	3.03	3.17	2.88	2.83	2.92
By Sex																		
Female	2.68	2.58	2.77	2.98	2.88	3.07	2.93	2.84	3.03	3.03	2.94	3.12	3.11	3.00	3.21	2.94	2.88	3.01
Male	2.45	2.37	2.53	2.79	2.70	2.87	2.79	2.70	2.87	2.97	2.88	3.06	3.10	3.00	3.20	2.82	2.76	2.88
By Age																		
30-39	2.79	2.50	3.08	3.22	2.93	3.51	3.11	2.77	3.44	3.18	2.84	3.52	3.12	2.76	3.49	3.09	2.88	3.31
40-49	2.36	2.21	2.51	2.73	2.55	2.91	2.74	2.56	2.91	2.75	2.55	2.94	2.76	2.56	2.97	2.70	2.56	2.84
50-59	2.47	2.35	2.60	2.80	2.67	2.93	2.76	2.62	2.89	2.96	2.83	3.10	3.05	2.90	3.21	2.81	2.71	2.90
60-69	2.54	2.43	2.64	2.81	2.71	2.92	2.84	2.73	2.95	3.05	2.94	3.17	3.11	2.98	3.24	2.86	2.78	2.94
70-79	2.73	2.59	2.86	3.03	2.89	3.17	2.98	2.86	3.10	3.06	2.94	3.17	3.30	3.17	3.43	3.01	2.93	3.10
By Socio-Economic Status																		
Quintile 1 (Low)	2.74	2.60	2.89	3.09	2.94	3.25	3.03	2.87	3.18	3.31	3.15	3.47	3.39	3.23	3.56	3.06	2.94	3.17
Quintile 2	2.58	2.44	2.72	2.80	2.66	2.93	2.28	2.68	2.96	2.92	2.79	3.06	3.10	2.95	3.25	2.88	2.78	2.98
Quintile 3	2.47	2.34	2.60	2.70	2.57	2.83	2.68	2.56	2.81	3.04	2.91	3.18	3.10	2.95	3.25	2.69	2.60	2.78
Quintile 4	2.55	2.41	2.70	2.95	2.80	3.09	2.83	2.69	2.96	2.81	2.67	2.95	2.82	2.68	2.96	2.89	2.78	2.99
Quintile 5 (High)	2.57	2.40	2.74	2.92	2.74	3.10	3.01	2.83	3.20	2.87	2.70	3.03	3.15	2.92	3.38	2.96	2.83	3.08
By Morbidity																		
Very Low	0.83	0.63	1.03	0.82	0.64	1.00	0.40	0.29	0.51	0.37	0.27	0.47	0.90	0.71	1.08	0.67	0.57	0.76
Low	1.11	1.02	1.21	1.16	1.07	1.26	0.68	0.62	0.75	0.71	0.65	0.77	1.29	1.18	1.39	0.99	0.94	1.04
Medium	1.57	1.48	1.66	1.71	1.63	1.80	1.17	1.12	1.23	1.29	1.22	1.35	1.80	1.71	1.90	1.51	1.46	1.56
High	2.43	2.34	2.52	2.67	2.57	2.76	2.48	2.40	2.56	2.59	2.51	2.67	2.98	2.87	3.09	2.63	2.57	2.69
Very High	4.14	3.99	4.30	4.78	4.61	4.94	5.57	5.40	5.74	5.85	5.68	6.02	5.12	4.95	5.30	5.09	4.98	5.21
By Disease-Specific Severity Index																		
No Complications	2.00	1.90	2.09	2.19	2.10	2.29	1.86	1.78	1.94	1.95	1.87	2.03	2.23	2.14	2.33	2.05	1.98	2.11
1 or More Minor Complications	2.40	2.30	2.50	2.74	2.63	2.84	2.65	2.55	2.76	2.75	2.65	2.86	2.93	2.82	3.05	2.70	2.62	2.77
1 or More Intermediate Complications	3.03	2.92	3.15	3.44	3.32	3.57	3.67	3.55	3.80	3.91	3.78	4.03	3.86	3.72	4.01	3.59	3.50	3.67
1 Major Complication	4.42	3.57	5.28	4.64	3.92	5.36	5.41	4.68	6.14	5.74	5.00	6.48	5.54	4.66	6.41	5.15	4.59	5.71
2 or More Major Complications	5.60	4.68	6.52	6.62	5.63	7.62	8.76	7.51	10.02	8.93	7.83	10.03	7.03	5.98	8.07	7.39	6.67	8.11
By Patient Residence																		
LHA 202 - S. Surrey / WR	2.49	2.24	2.73	2.95	2.66	3.23	2.67	2.43	2.91	2.94	2.71	3.16	3.30	2.95	3.65	2.89	2.70	3.08
LHA 201 - Surrey	2.82	2.67	2.96	3.03	2.88	3.17	2.98	2.84	3.12	3.17	3.03	3.32	3.22	3.08	3.37	3.04	2.94	3.15
LHA 076 - Agassiz-Harrison	1.40	0.99	1.81	1.83	1.37	2.29	2.25	1.66	2.84	2.12	1.55	2.69	2.35	1.70	2.99	1.96	1.61	2.31
LHA 075 - Mission	1.87	1.60	2.15	2.43	2.10	2.76	2.36	2.05	2.68	2.44	2.14	2.73	2.28	2.01	2.56	2.28	2.09	2.48
LHA 043 - Coquitlam	2.62	2.43	2.80	2.96	2.77	3.14	2.94	2.76	3.13	2.98	2.80	3.16	3.19	2.98	3.40	2.95	2.81	3.08
LHA 042 - Maple Ridge	2.26	2.00	2.52	2.52	2.29	2.74	2.79	2.52	3.06	2.97	2.70	3.24	2.81	2.54	3.08	2.68	2.49	2.86
LHA 041 - Burnaby	2.63	2.49	2.78	2.95	2.79	3.12	2.92	2.76	3.08	3.15	2.98	3.32	3.17	2.99	3.35	2.97	2.85	3.09
LHA 040 - New Westminster	3.03	2.71	3.35	3.51	3.16	3.87	3.17	2.86	3.49	3.39	3.06	3.72	3.56	3.19	3.93	3.28	3.05	3.52
LHA 037 - Delta	2.76	2.53	2.98	3.29	3.02	3.57	3.25	2.98	3.52	3.14	2.90	3.39	3.38	3.11	3.66	3.15	2.97	3.33
LHA 035 - Langley	2.56	2.33	2.78	2.66	2.45	2.87	2.83	2.58	3.07	2.94	2.73	3.16	3.01	2.76	3.25	2.80	2.62	2.97
LHA 034 - Abbotsford	2.04	1.88	2.20	2.48	2.29	2.67	2.42	2.24	2.60	2.55	2.36	2.74	2.95	2.71	3.19	2.49	2.36	2.62
LHA 033 - Chilliwack	1.96	1.77	2.15	2.37	2.15	2.59	2.48	2.25	2.71	2.68	2.43	2.92	2.49	2.24	2.73	2.41	2.25	2.56
LHA 032 - Hope	1.75	1.26	2.25	1.86	1.28	2.43	2.26	1.68	2.83	2.21	1.52	2.90	2.93	2.08	3.79	2.23	1.82	2.65

Information on the utilization of specialist physician costs as a binary variable is indicated on table D-6. Based on this information, adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority who are in the low adherence group are less likely to be in the high utilization of specialist physician costs category (11.2%; 95% CI 10.4%, 12.1%) compared to individuals in the medium adherence group (18.9%; 95% CI 18.1%, 19.7%). Individuals in the medium adherence group, on the other hand, are less likely to be in the high utilization category than individuals in the high adherence group (29.8%; 95% CI 28.6%, 31.0%).

Table D-6 Proportion of Adults with Diagnosed Diabetes
High Utilization of Average Annual Specialist Physician Dollars

	Total N in Year 3	N	%	95% CI	
Total Population	20,228	4,039	20.0%	19.5%	20.6%
By Level of Adherence					
Low	5,136	576	11.2%	10.4%	12.1%
Medium	9,448	1,782	18.9%	18.1%	19.7%
Hiigh	5,644	1,681	29.8%	28.6%	31.0%
By Sex					
Female	9,256	1,911	20.6%	19.9%	21.5%
Male	10,917	2,119	19.4%	18.7%	20.2%
By Age *(in Year 3)*					
30-39	1,081	212	19.6%	17.4%	22.1%
40-49	2,795	457	16.4%	15.0%	17.8%
50-59	5,054	965	19.1%	18.0%	20.2%
60-69	6,205	1,237	19.9%	19.0%	21.0%
70-79	5,093	1,168	22.9%	21.8%	24.1%
By Socio-Economic Status *(in Year 3)*					
Quintile 1 (Low)	4,026	881	21.9%	20.7%	23.2%
Quintile 2	4,330	870	20.1%	18.9%	21.3%
Quintile 3	4,638	836	18.0%	17.0%	19.2%
Quintile 4	4,121	818	19.8%	18.7%	21.1%
Quintile 5 (High)	2,706	569	21.0%	19.6%	22.6%
By Morbidity					
Very Low	334	-	0.0%		
Low	2,186	35	1.6%	1.2%	2.2%
Medium	4,500	215	4.8%	4.2%	5.4%
High	7,449	1,186	15.9%	15.1%	16.8%
Very High	5,622	2,543	45.2%	44.0%	46.6%
By Disease-Specific Severity Index					
No Complications	6,366	685	10.8%	10.0%	11.6%
1 or More Minor Complications	6,951	1,264	18.2%	17.3%	19.1%
1 or More Intermediate Complications	6,289	1,772	28.2%	27.1%	29.3%
1 Major Complication	338	145	42.9%	37.7%	48.2%
2 or More Major Complications	285	173	60.7%	55.3%	66.5%
By Patient Residence *(in Year 3)*					
LHA 202 - S. Surrey / WR	1,035	210	20.3%	18.0%	22.9%
LHA 201 - Surrey	4,861	1,020	21.0%	19.9%	22.2%
LHA 076 - Agassiz-Harrison	123	15	12.2%	7.5%	19.2%
LHA 075 - Mission	560	80	14.3%	11.6%	17.4%
LHA 043 - Coquitlam	2,434	471	19.4%	17.9%	21.0%
LHA 042 - Maple Ridge	1,056	185	17.5%	15.4%	19.9%
LHA 041 - Burnaby	3,253	714	21.9%	20.6%	23.4%
LHA 040 - New Westminster	903	217	24.0%	21.4%	26.9%
LHA 037 - Delta	1,404	328	23.4%	15.1%	19.0%
LHA 035 - Langley	1,564	294	18.8%	16.9%	20.8%
LHA 034 - Abbotsford	1,837	315	17.1%	15.5%	18.9%
LHA 033 - Chilliwack	1,065	166	15.6%	13.6%	18.0%
LHA 032 - Hope	133	24	18.0%	12.4%	25.5%

While there is no significant difference between females and males, there appears to be a clear trend based on both morbidity and disease-specific severity index variables, with individuals in the lower morbidity and severity groups less likely to be in the high utilization category than individuals in the higher morbidity and severity groups.

Individuals aged 70-79 (22.9%; 95% CI 21.8%, 24.1%) are more likely to be in the high utilization category than 40-69 year olds, but not 30-39 year olds.

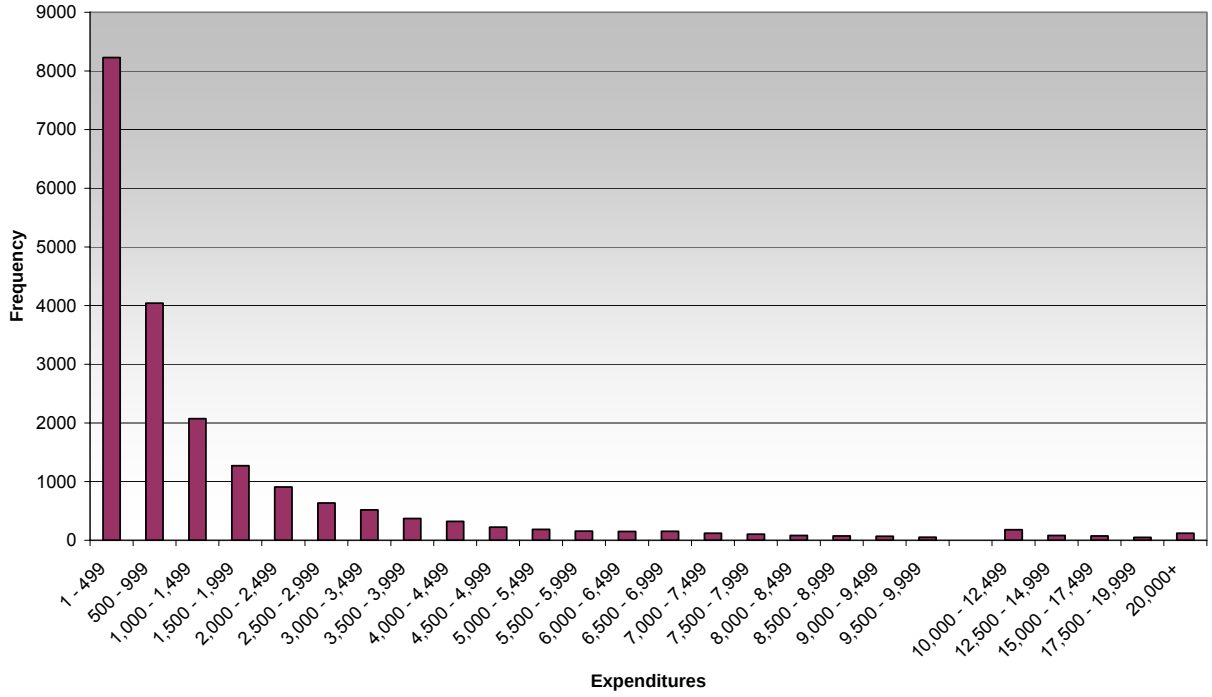
The results for socio-economic status (SES) are mixed. Individuals in the middle SES (quintile 3) category appear less likely to be in the high utilization category (18.0%; 95% CI 17.0%, 19.2%) than either individuals in the highest (quintile 5) or lowest (quintile 1) SES category (21.0%; 95% CI 19.6%, 22.6% and 21.9%; 95% CI 20.7%, 23.2%).

The proportion of adults with diagnosed type 2 diabetes in the high utilization of specialist physician cost category by local health area (LHA) ranges from 12.2% (95% CI; 7.5%, 19.2%) in the LHA of Agassiz-Harrison to 24.0% (95% CI; 21.4%; 26.9%) in the LHA of New Westminster.

Total Costs

The frequency distribution for the mean annual total costs over the five year period is shown in Figure D-4. The mean annual total costs for the 20,228 subjects in the study were $1,762 per person per year (median of $690, range from $16 to $75,622).

Figure D-4 Frequency Distribution for
Average Annual Total Costs



Information on the utilization of total costs on a year by year basis by adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority is provided in table D-7. Mean utilization of total costs in constant 2000/01 fiscal year dollars increased from $1,499 (95% CI; $1,384, $1,514) per person in 1996/97 to $2,140 (95% CI; $2,033, $2,247) in 2000/01. During the five year period, an average of $1,762 (95% CI; $1,718, $1,807) in total costs were utilized per person per year.

Table D-7 Adults with Diagnosed Diabetes
Mean Total Costs (Constant 2000 $)

	1996/97			1997/98			1998/99			1999/00			2000/01			All Years		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Total Population	$1,449	1,384	1,514	$1,650	1,576	1,723	$1,709	1,632	1,787	$1,863	1,786	1,940	$2,140	2,033	2,247	$1,762	1,718	1,807
By Sex																		
Female	1,528	1,426	1,631	1,703	1,593	1,812	1,694	1,586	1,802	1,921	1,807	2,034	2,232	2,061	2,403	1,815	1,747	1,884
Male	1,380	1,298	1,463	1,598	1,499	1,697	1,720	1,610	1,830	1,811	1,705	1,917	2,062	1,927	2,197	1,714	1,656	1,773
By Age																		
30-39	1,147	969	1,325	1,089	949	1,228	1,186	962	1,411	1,258	985	1,532	1,449	959	1,938	1,222	1,052	1,392
40-49	983	883	1,083	1,219	1,031	1,407	1,162	991	1,332	1,158	1,022	1,294	1,308	1,036	1,580	1,183	1,083	1,284
50-59	1,208	1,096	1,320	1,356	1,226	1,486	1,357	1,218	1,495	1,367	1,250	1,483	1,498	1,343	1,653	1,367	1,293	1,440
60-69	1,542	1,416	1,667	1,683	1,552	1,814	1,674	1,548	1,800	1,876	1,730	2,022	1,996	1,817	2,176	1,743	1,667	1,820
70-79	2,139	1,942	2,336	2,393	2,204	2,582	2,514	2,313	2,715	2,596	2,419	2,773	3,137	2,875	3,400	2,611	2,500	2,721
By Socio-Economic Status																		
Quintile 1 (Low)	1,600	1,450	1,751	1,861	1,697	2,025	2,039	1,822	2,257	2,256	2,053	2,459	2,568	2,304	2,833	2,039	1,924	2,155
Quintile 2	1,473	1,332	1,614	1,597	1,443	1,750	1,667	1,497	1,836	1,880	1,703	2,056	2,299	2,042	2,555	1,288	1,690	1,887
Quintile 3	1,407	1,275	1,539	1,522	1,367	1,677	1,581	1,428	1,735	1,846	1,690	2,002	2,024	1,807	2,240	1,584	1,503	1,666
Quintile 4	1,400	1,246	1,553	1,606	1,440	1,771	1,578	1,434	1,721	1,604	1,454	1,753	1,835	1,629	2,040	1,673	1,582	1,765
Quintile 5 (High)	1,263	1,112	1,415	1,559	1,354	1,763	1,644	1,461	1,827	1,587	1,408	1,765	1,844	1,575	2,112	1,645	1,533	1,757
By Morbidity																		
Very Low	479	305	652	347	257	437	146	104	187	141	98	184	446	286	607	312	259	365
Low	593	491	694	575	494	655	211	193	229	219	202	236	769	618	920	473	432	515
Medium	883	771	996	823	741	906	428	402	455	478	447	509	1,024	911	1,137	727	687	768
High	1,344	1,246	1,442	1,524	1,415	1,634	1,227	1,155	1,298	1,364	1,273	1,454	2,030	1,872	2,187	1,498	1,443	1,552
Very High	2,443	2,278	2,608	2,975	2,771	3,179	4,033	3,783	4,283	4,363	4,127	4,600	3,833	3,534	4,132	3,529	3,403	3,655
By Disease-Specific Severity Index																		
No Complications	1,063	960	1,167	1,049	958	1,141	796	728	865	825	759	891	1,252	1,141	1,364	997	949	1,046
1 or More Minor Complications	1,363	1,255	1,470	1,547	1,443	1,652	1,616	1,485	1,747	1,573	1,473	1,673	1,866	1,715	2,016	1,593	1,529	1,657
1 or More Intermediate Complications	1,748	1,628	1,867	2,174	2,001	2,347	2,274	2,121	2,426	2,717	2,537	2,896	2,951	2,728	3,174	2,373	2,279	2,466
1 Major Complication	3,052	2,179	3,925	2,989	2,259	3,719	4,558	3,267	5,849	5,519	4,247	6,792	4,982	2,932	7,033	4,220	3,537	4,903
2 or More Major Complications	3,679	2,722	4,636	4,418	3,424	5,412	8,573	6,877	10,268	8,967	7,329	10,606	7,424	4,769	10,079	6,612	5,684	7,540
By Patient Residence																		
LHA 202 - S. Surrey / WR	1,270	1,083	1,457	1,497	1,258	1,736	1,505	1,264	1,747	2,026	1,715	2,338	2,628	2,016	3,239	1,808	1,621	1,994
LHA 201 - Surrey	1,501	1,376	1,626	1,662	1,496	1,828	1,725	1,543	1,907	1,802	1,638	1,966	1,991	1,745	2,236	1,742	1,641	1,843
LHA 076 - Agassiz-Harrison	3,266	484	6,049	1,988	1,064	2,913	1,782	1,013	2,550	1,502	466	2,538	2,625	1,041	4,208	2,203	1,267	3,139
LHA 075 - Mission	1,564	1,115	2,013	2,140	1,236	3,044	1,885	1,486	2,283	1,638	1,305	1,972	1,815	1,424	2,207	1,860	1,573	2,148
LHA 043 - Coquitlam	1,465	1,259	1,672	1,639	1,440	1,837	1,744	1,465	2,022	1,742	1,520	1,964	2,161	1,829	2,494	1,745	1,608	1,883
LHA 042 - Maple Ridge	1,388	1,125	1,651	1,590	1,335	1,844	2,029	1,704	2,353	1,889	1,619	2,160	2,042	1,637	2,448	1,786	1,620	1,953
LHA 041 - Burnaby	1,269	1,123	1,416	1,401	1,271	1,532	1,432	1,258	1,606	1,726	1,519	1,934	1,762	1,545	1,979	1,530	1,435	1,625
LHA 040 - New Westminster	1,919	1,446	2,392	2,074	1,571	2,577	2,133	1,744	2,521	2,312	1,879	2,746	2,574	2,064	3,084	2,133	1,883	2,382
LHA 037 - Delta	1,254	1,072	1,437	1,606	1,376	1,837	1,599	1,348	1,851	1,735	1,457	2,014	1,925	1,637	2,213	1,607	1,472	1,743
LHA 035 - Langley	1,508	1,270	1,746	1,498	1,293	1,703	1,742	1,502	1,983	2,065	1,770	2,361	2,430	2,013	2,846	1,851	1,691	2,011
LHA 034 - Abbotsford	1,498	1,284	1,711	1,887	1,646	2,127	1,742	1,528	1,957	1,843	1,618	2,069	2,508	2,172	2,844	1,884	1,745	2,022
LHA 033 - Chilliwack	1,354	1,145	1,562	1,839	1,489	2,188	1,672	1,413	1,930	2,213	1,884	2,542	2,256	1,858	2,653	1,877	1,695	2,059
LHA 032 - Hope	1,832	1,136	2,527	1,492	719	2,264	3,254	2,033	4,474	2,708	1,572	3,844	3,846	2,117	5,575	2,631	1,918	3,345

Information on the utilization of total costs as a binary variable is indicated on table D-8. Based on this information, adults with diagnosed type 2 diabetes living in the geographic boundaries of the Fraser Health Authority who are in the low adherence group are less likely to be in the high utilization of total costs category (16.5%; 95% CI 15.5%, 17.6%) compared to individuals in the medium or high adherence group (20.9%; 95% CI 20.1%, 21.7 and 21.5%; 95% CI 20.5%, 22.6%, respectively).

While there is no significant difference between females and males, there appears to be a clear trend based on age, morbidity and disease-specific severity index variables, with younger individuals, those in the lower morbidity and those in the lower severity groups less likely to be in the high utilization category than individuals in the higher morbidity and severity groups.

Table D-8 Proportion of Adults with Diagnosed Diabetes
With Low or High Utilization of Average Annual Total Costs

	Total N in Year 3	Low Utilization N	Low Utilization %	Low Utilization 95% CI		High Utilization N	High Utilization %	High Utilization 95% CI	
Total Population	20,228	16,190	80.0%	79.4%	80.5%	4,038	20.0%	19.5%	20.6%
By Level of Adherence									
Low	5,136	4,287	83.5%	82.4%	85.5%	849	16.5%	15.5%	17.6%
Medium	9,448	7,475	79.1%	78.3%	80.0%	1,973	20.9%	20.1%	21.7%
High	5,644	4,428	78.5%	77.4%	79.5%	1,216	21.5%	20.5%	22.6%
By Sex									
Female	9,256	7,432	80.3%	79.5%	81.1%	1,824	19.7%	18.9%	20.5%
Male	10,917	8,713	79.8%	79.1%	80.6%	2,204	20.2%	19.5%	21.0%
By Age									
30-39	1,081	967	89.5%	87.5%	91.1%	114	10.5%	8.9%	12.5%
40-49	2,795	2,501	89.5%	88.3%	90.6%	294	10.5%	9.4%	11.7%
50-59	5,054	4,304	85.2%	84.2%	86.1%	750	14.8%	13.9%	15.9%
60-69	6,205	4,967	80.0%	79.0%	81.0%	1,238	20.0%	19.0%	21.0%
70-79	5,093	3,451	67.8%	66.5%	69.0%	1,642	32.2%	31.0%	33.5%
By Socio-Economic Status									
Quintile 1 (Low)	4,026	3,094	76.9%	75.5%	78.1%	932	23.1%	21.9%	24.5%
Quintile 2	4,330	3,460	79.9%	78.7%	81.1%	870	20.1%	18.9%	21.3%
Quintile 3	4,638	3,802	82.0%	80.8%	83.1%	836	18.0%	17.0%	19.2%
Quintile 4	4,121	3,331	80.8%	79.6%	82.0%	790	19.2%	18.0%	20.4%
Quintile 5 (High)	2,706	2,197	81.2%	79.7%	82.6%	509	18.8%	17.4%	20.3%
By Morbidity									
Very Low	334	328	98.2%	96.1%	99.2%	6	1.8%	0.8%	3.9%
Low	2,186	2,113	96.7%	95.8%	97.3%	73	3.3%	2.7%	4.2%
Medium	4,500	4,252	94.5%	93.8%	95.1%	248	5.5%	4.9%	6.2%
High	7,449	6,173	82.9%	82.0%	83.7%	1,276	17.1%	16.3%	18.0%
Very High	5,622	3,211	57.1%	55.7%	58.3%	2,411	42.9%	41.7%	44.3%
By Disease-Specific Severity Index									
No Complications	6,366	5,758	90.4%	89.7%	91.2%	608	9.6%	8.9%	10.3%
1 or More Minor Complications	6,951	5,649	81.3%	80.3%	82.1%	1,302	18.7%	17.9%	19.7%
1 or More Intermediate Complications	6,289	4,500	71.6%	70.4%	72.6%	1,789	28.4%	27.4%	29.6%
1 Major Complication	338	189	55.9%	50.6%	61.1%	149	44.1%	38.9%	49.4%
2 or More Major Complications	284	94	33.1%	27.9%	38.6%	190	66.9%	61.2%	72.1%
By Patient Residence									
LHA 202 - S. Surrey / WR	1,035	805	77.8%	75.2%	80.2%	230	22.2%	19.8%	24.9%
LHA 201 - Surrey	4,861	3,958	81.4%	80.3%	82.5%	903	18.6%	17.5%	19.7%
LHA 076 - Agassiz-Harrison	123	96	78.0%	70.0%	84.5%	27	22.0%	15.6%	30.1%
LHA 075 - Mission	560	441	78.8%	75.2%	81.9%	119	21.3%	18.1%	24.8%
LHA 043 - Coquitlam	2,434	1,991	81.8%	80.2%	83.3%	443	18.2%	16.8%	19.8%
LHA 042 - Maple Ridge	1,056	816	77.3%	74.7%	79.7%	240	22.7%	20.3%	25.4%
LHA 041 - Burnaby	3,253	2,708	83.2%	81.9%	84.5%	545	16.8%	15.5%	18.1%
LHA 040 - New Westminster	903	685	75.9%	73.0%	78.5%	218	24.1%	21.5%	27.0%
LHA 037 - Delta	1,404	1,133	80.7%	78.6%	82.7%	271	19.3%	17.3%	21.5%
LHA 035 - Langley	1,564	1,218	77.9%	75.8%	78.9%	346	22.1%	20.1%	24.2%
LHA 034 - Abbotsford	1,837	1,425	77.6%	75.6%	79.4%	412	22.4%	20.6%	24.4%
LHA 033 - Chilliwack	1,065	821	77.1%	74.5%	79.5%	244	22.9%	20.5%	25.5%
LHA 032 - Hope	133	93	69.9%	61.7%	77.1%	40	30.1%	22.9%	38.3%

Individuals aged 70-79 (32.2%; 95% CI 31.0%, 33.5%), for example, are more likely to be in the high utilization category than 30-39 year olds (10.5%; 95% CI 8.9%, 12.5%).

The descriptive results for socio-economic status (SES) suggest that only individuals in the lowest SES (quintile 1) category appear more likely to be in the high utilization category (23.1%; 95% CI 21.9%, 24.5%) than individuals in any of the other four quintiles.

The proportion of adults with diagnosed type 2 diabetes in the high utilization of total cost category by local health area (LHA) ranges from 16.8% (95% CI; 15.5%, 18.1%) in the LHA of Burnaby to 30.1% (95% CI; 22.9%; 38.3%) in the LHA of Hope.

Appendix E: Calculation of Change in Acute Care, Physician and Total Costs with Improved Adherence

Table E-1: Mean Annual Costs per Capita
By Level of Adherence and Level of Morbidity

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low			Low			Medium			High			Very High			Total		
		N =	177			928			1,419			1,596			954			5,136		
			Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
Low	Acute		*$148*	*$81*	*$216*	*$242*	*$175*	*$309*	*$428*	*$345*	*$511*	*$1,292*	*$1,150*	*$1,434*	*$3,616*	*$3,220*	*$4,011*	*$1,252*	*$1,157*	*$1,348*
(0-9)	Physician		*$135*	*$124*	*$146*	*$176*	*$170*	*$183*	*$251*	*$243*	*$260*	*$404*	*$392*	*$417*	*$753*	*$725*	*$782*	*$378*	*$369*	*$387*
	Total		***$283***	***$209***	***$358***	***$419***	***$348***	***$489***	***$680***	***$592***	***$767***	***$1,696***	***$1,547***	***$1,845***	***$4,369***	***$3,956***	***$4,782***	***$1,630***	***$1,529***	***$1,732***
		N =	122			904			2,104			3,577			2,696			9,448		
Medium			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
(10-14)	Acute		*$130*	*$71*	*$190*	*$256*	*$198*	*$315*	*$415*	*$368*	*$461*	*$1,054*	*$981*	*$1,127*	*$2,758*	*$2,585*	*$2,930*	*$1,310*	*$1,249*	*$1,371*
	Physician		*$184*	*$170*	*$199*	*$238*	*$231*	*$246*	*$315*	*$308*	*$322*	*$451*	*$442*	*$459*	*$791*	*$774*	*$808*	*$495*	*$488*	*$502*
	Total		***$315***	***$247***	***$382***	***$495***	***$432***	***$557***	***$730***	***$679***	***$780***	***$1,505***	***$1,427***	***$1,582***	***$3,549***	***$3,366***	***$3,732***	***$1,805***	***$1,739***	***$1,870***
		N =	35			354			977			2,276			1,972			5,644		
High			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
(15-23)	Acute		*$200*	*-$33*	*$434*	*$274*	*$201*	*$346*	*$434*	*$355*	*$513*	*$849*	*$774*	*$923*	*$2,241*	*$2,091*	*$2,392*	*$1,226*	*$1,160*	*$1,291*
	Physician		*$245*	*$217*	*$272*	*$289*	*$276*	*$301*	*$358*	*$349*	*$368*	*$499*	*$488*	*$509*	*$855*	*$834*	*$876*	*$585*	*$575*	*$596*
	Total		***$445***	***$198***	***$692***	***$562***	***$483***	***$641***	***$792***	***$708***	***$876***	***$1,347***	***$1,267***	***$1,428***	***$3,096***	***$2,935***	***$3,258***	***$1,811***	***$1,740***	***$1,883***
		N =	334			2,186			4,500			7,449			5,622			20,228		
Total			*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
	Acute		*$147*	*$99*	*$195*	*$253*	*$214*	*$292*	*$423*	*$385*	*$461*	*$1,042*	*$991*	*$1,094*	*$2,722*	*$2,603*	*$2,842*	*$1,272*	*$1,230*	*$1,313*
	Physician		*$164*	*$155*	*$174*	*$220*	*$215*	*$225*	*$304*	*$300*	*$309*	*$455*	*$449*	*$461*	*$807*	*$795*	*$819*	*$491*	*$485*	*$496*
	Total		***$312***	***$259***	***$365***	***$473***	***$432***	***$515***	***$727***	***$687***	***$768***	***$1,498***	***$1,443***	***$1,552***	***$3,529***	***$3,403***	***$3,655***	***$1,762***	***$1,718***	***$1,807***

Table E-2: Total Annual Costs
By Level of Adherence and Level of Morbidity

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
Low	Acute		*$26,277*	*$224,752*	*$607,474*	*$2,061,984*	*$3,449,511*	*$62,239*	*$6,432,238*
(0-9)	Physician		*$23,872*	*$163,773*	*$356,822*	*$645,534*	*$718,610*	*$32,763*	*$1,941,374*
	Total		***$50,149***	***$388,526***	***$964,296***	***$2,707,518***	***$4,168,121***	***$95,002***	***$8,373,612***
		N =	122	904	2,104	3,577	2,696	45	9,448
Medium	Acute		*$15,886*	*$231,677*	*$872,276*	*$3,770,587*	*$7,434,921*	*$49,253*	*$12,374,600*
(10-14)	Physician		*$22,489*	*$215,477*	*$662,634*	*$1,611,689*	*$2,132,967*	*$31,374*	*$4,676,630*
	Total		***$38,375***	***$447,155***	***$1,534,910***	***$5,382,276***	***$9,567,888***	***$80,626***	***$17,051,230***
		N =	35	354	977	2,276	1,972	30	5,644
High	Acute		*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
(15-23)	Physician		*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
	Total		***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
Total	Acute		*$49,176*	*$553,280*	*$1,903,475*	*$7,764,167*	*$15,304,473*	*$149,745*	*$25,724,317*
	Physician		*$54,929*	*$481,465*	*$1,369,642*	*$3,391,809*	*$4,537,657*	*$87,029*	*$9,922,530*
	Total		***$104,105***	***$1,034,745***	***$3,273,117***	***$11,155,976***	***$19,842,130***	***$236,774***	***$35,646,847***

Table E-3: Total Annual Costs

By Level of Adherence and Level of Morbidity

If Low Adherence Groups Move to Medium Adherence

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
	Low	Acute	*$23,047*	*$237,828*	*$588,289*	*$1,682,376*	*$2,630,903*	*$67,859*	*$5,230,302*
	(0-9)	Physician	*$32,628*	*$221,198*	*$446,900*	*$719,110*	*$754,767*	*$43,226*	*$2,217,828*
		Total	***$55,675***	***$459,026***	***$1,035,189***	***$2,401,485***	***$3,385,670***	***$111,085***	***$7,448,130***
		N =	122	904	2,104	3,577	2,696	45	9,448
	Medium	Acute	*$15,886*	*$231,677*	*$872,276*	*$3,770,587*	*$7,434,921*	*$49,253*	*$12,374,600*
	(10-14)	Physician	*$22,489*	*$215,477*	*$662,634*	*$1,611,689*	*$2,132,967*	*$31,374*	*$4,676,630*
		Total	***$38,375***	***$447,155***	***$1,534,910***	***$5,382,276***	***$9,567,888***	***$80,626***	***$17,051,230***
		N =	35	354	977	2,276	1,972	30	5,644
	High	Acute	*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
	(15-23)	Physician	*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
		Total	***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
	Total	Acute	*$45,946*	*$566,356*	*$1,884,290*	*$7,384,558*	*$14,485,865*	*$155,365*	*$24,522,380*
		Physician	*$63,685*	*$538,889*	*$1,459,720*	*$3,465,385*	*$4,573,814*	*$97,492*	*$10,198,984*
		Total	***$109,631***	***$1,105,245***	***$3,344,010***	***$10,849,943***	***$19,059,679***	***$252,857***	***$34,721,365***

Table E-4: Total Annual Costs

By Level of Adherence and Level of Morbidity

If Medium Adherence Groups Move to High Adherence

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
	Low	Acute	*$26,277*	*$224,752*	*$607,474*	*$2,061,984*	*$3,449,511*	*$62,239*	*$6,432,238*
	(0-9)	Physician	*$23,872*	*$163,773*	*$356,822*	*$645,534*	*$718,610*	*$32,763*	*$1,941,374*
		Total	***$50,149***	***$388,526***	***$964,296***	***$2,707,518***	***$4,168,121***	***$95,002***	***$8,373,612***
		N =	122	904	2,104	3,577	2,696	45	9,448
	Medium	Acute	*$24,446*	*$247,325*	*$912,505*	*$3,035,728*	*$6,042,814*	*$57,380*	*$10,320,200*
	(10-14)	Physician	*$29,863*	*$261,021*	*$754,137*	*$1,783,135*	*$2,305,107*	*$34,339*	*$5,167,601*
		Total	***$54,310***	***$508,346***	***$1,666,642***	***$4,818,863***	***$8,347,921***	***$91,719***	***$15,487,801***
		N =	35	354	977	2,276	1,972	30	5,644
	High	Acute	*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
	(15-23)	Physician	*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
		Total	***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
	Total	Acute	*$57,737*	*$568,929*	*$1,943,704*	*$7,029,308*	*$13,912,367*	*$157,873*	*$23,669,917*
		Physician	*$62,302*	*$527,008*	*$1,461,145*	*$3,563,255*	*$4,709,797*	*$89,994*	*$10,413,500*
		Total	***$120,040***	***$1,095,937***	***$3,404,848***	***$10,592,563***	***$18,622,163***	***$247,867***	***$34,083,418***

Table E-5: Total Annual Costs

By Level of Adherence and Level of Morbidity

If Low Adherence Groups Move to High Adherence

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
	Low *(0-9)*	Acute	*$35,467*	*$253,892*	*$615,420*	*$1,354,493*	*$2,138,296*	*$79,057*	*$4,476,625*
		Physician	*$43,326*	*$267,951*	*$508,612*	*$795,606*	*$815,680*	*$47,311*	*$2,478,485*
		Total	***$78,793***	***$521,842***	***$1,124,032***	***$2,150,099***	***$2,953,975***	***$126,368***	***$6,955,111***
		N =	122	904	2,104	3,577	2,696	45	9,448
	Medium *(10-14)*	Acute	*$15,886*	*$231,677*	*$872,276*	*$3,770,587*	*$7,434,921*	*$49,253*	*$12,374,600*
		Physician	*$22,489*	*$215,477*	*$662,634*	*$1,611,689*	*$2,132,967*	*$31,374*	*$4,676,630*
		Total	***$38,375***	***$447,155***	***$1,534,910***	***$5,382,276***	***$9,567,888***	***$80,626***	***$17,051,230***
		N =	35	354	977	2,276	1,972	30	5,644
	High *(15-23)*	Acute	*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
		Physician	*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
		Total	***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
	Total	Acute	*$58,366*	*$582,420*	*$1,911,422*	*$7,056,676*	*$13,993,257*	*$166,564*	*$23,768,704*
		Physician	*$74,383*	*$585,642*	*$1,521,432*	*$3,541,881*	*$4,634,727*	*$101,577*	*$10,459,641*
		Total	***$132,749***	***$1,168,062***	***$3,432,854***	***$10,598,557***	***$18,627,984***	***$268,140***	***$34,228,346***

Table E-6: Total Annual Costs

By Level of Adherence and Level of Morbidity

If Low Adherence Groups Move to Medium Adherence
And Medium Adherence Groups Move to High Adherence

Level of Morbidity →

Adherence to Recommended Tests & Procedures			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
	Low *(0-9)*	Acute	*$23,047*	*$237,828*	*$588,289*	*$1,682,376*	*$2,630,903*	*$67,859*	*$5,230,302*
		Physician	*$32,628*	*$221,198*	*$446,900*	*$719,110*	*$754,767*	*$43,226*	*$2,217,828*
		Total	***$55,675***	***$459,026***	***$1,035,189***	***$2,401,485***	***$3,385,670***	***$111,085***	***$7,448,130***
		N =	122	904	2,104	3,577	2,696	45	9,448
	Medium *(10-14)*	Acute	*$24,446*	*$247,325*	*$912,505*	*$3,035,728*	*$6,042,814*	*$57,380*	*$10,320,200*
		Physician	*$29,863*	*$261,021*	*$754,137*	*$1,783,135*	*$2,305,107*	*$34,339*	*$5,167,601*
		Total	***$54,310***	***$508,346***	***$1,666,642***	***$4,818,863***	***$8,347,921***	***$91,719***	***$15,487,801***
		N =	35	354	977	2,276	1,972	30	5,644
	High *(15-23)*	Acute	*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
		Physician	*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
		Total	***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
	Total	Acute	*$54,507*	*$582,004*	*$1,924,519*	*$6,649,700*	*$13,093,758*	*$163,493*	*$22,467,980*
		Physician	*$71,059*	*$584,433*	*$1,551,223*	*$3,636,830*	*$4,745,953*	*$100,457*	*$10,689,955*
		Total	***$125,565***	***$1,166,437***	***$3,475,741***	***$10,286,530***	***$17,839,712***	***$263,950***	***$33,157,935***

Table E-7: Total Annual Costs

By Level of Adherence and Level of Morbidity

If Low & Medium Adherence Groups Move to High Adherence

Level of Morbidity →

Adherence to Recommended Tests & Procedures ↕

			Very Low	Low	Medium	High	Very High	Pregnancy	Total
		N =	177	928	1,419	1,596	954	62	5,136
Low	*(0-9)*	Acute	*$35,467*	*$253,892*	*$615,420*	*$1,354,493*	*$2,138,296*	*$79,057*	*$4,397,630*
		Physician	*$43,326*	*$267,951*	*$508,612*	*$795,606*	*$815,680*	*$47,311*	*$2,510,232*
		Total	***$78,793***	***$521,842***	***$1,124,032***	***$2,150,099***	***$2,953,975***	***$126,368***	***$6,907,862***
		N =	122	904	2,104	3,577	2,696	45	9,448
Medium	*(10-14)*	Acute	*$24,446*	*$247,325*	*$912,505*	*$3,035,728*	*$6,042,814*	*$57,380*	*$10,262,864*
		Physician	*$29,863*	*$261,021*	*$754,137*	*$1,783,135*	*$2,305,107*	*$34,339*	*$5,190,643*
		Total	***$54,310***	***$508,346***	***$1,666,642***	***$4,818,863***	***$8,347,921***	***$91,719***	***$15,453,507***
		N =	35	354	977	2,276	1,972	30	5,644
High	*(15-23)*	Acute	*$7,013*	*$96,851*	*$423,725*	*$1,931,596*	*$4,420,041*	*$38,254*	*$6,917,479*
		Physician	*$8,567*	*$102,214*	*$350,186*	*$1,134,586*	*$1,686,080*	*$22,892*	*$3,304,525*
		Total	***$15,581***	***$199,065***	***$773,911***	***$3,066,182***	***$6,106,121***	***$61,146***	***$10,222,005***
		N =	334	2,186	4,500	7,449	5,622	137	20,228
Total		Acute	*$66,927*	*$598,068*	*$1,951,650*	*$6,321,817*	*$12,601,151*	*$174,691*	*$21,577,973*
		Physician	*$81,757*	*$631,186*	*$1,612,935*	*$3,713,327*	*$4,806,866*	*$104,542*	*$11,005,400*
		Total	***$148,683***	***$1,229,253***	***$3,564,585***	***$10,035,144***	***$17,408,017***	***$279,233***	***$32,583,374***