PREVALENCE OF DIABETES MELLITUS IN THE ABORIGINAL AND NON-ABORIGINAL PEOPLE LIVING IN THE BELLA COOLA VALLEY

by

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BSc., University of Northern British Columbia, 2001

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

COMMUNITY HEALTH SCIENCE

THE UNIVERSITY OF NORTHERN BRITISH COLUMBIA

March 2004

Your file Votre référence
ISBN: 0-494-04678-3
Our file Notre référence
ISBN: 0-494-04678-3

Abstract

The purpose of this study was to determine the prevalence rate of diabetes among the aboriginal and non-aboriginal populations of the Bella Coola Valley, British Columbia, as well as to explore the relationship between age, gender, weight, body mass index and aboriginal status, and the risk of developing type 2 diabetes in this community. A retrospective chart review was conducted on all residents living in the Bella Coola Valley as of September 2001 who had a clinic chart at the Bella Coola Medical Clinic. The age-adjusted prevalence of diabetes among the aboriginal population was 12.5%. Among the non-aboriginal population, the prevalence rate was similar to what has been reported for the general population of Canada (4.8%). It was determined that age, weight, body mass index and aboriginal status were all significant contributors to the risk of developing type 2 diabetes. The results of this study indicate that diabetes is a significant health issue that needs to be addressed in the Bella Coola Valley.

Table of Contents

		Page
Abstract		ii
Table of Contents		iii
List of Tables		iv
List of Figures		v
Acknowledgements		vi
Chapter One	Introduction	1
Chapter Two	Literature Review	4
	Diabetes Mellitus	4
	Diabetes and Aboriginal Populations	10
	Theories Behind the High Prevalence of Type 2 Diabetes in Aboriginal Populations	16
	Research Questions	21
Chapter Three	Methods	22
	Research Design	22
	Study Community	22
	Bella Coola Valley Population	26
	Health Services in the Bella Coola Valley	29
	Data Collection – The Bella Coola Valley Clinic Population	29
	Ethics Approval	32
	Data Analysis	33
Chapter Four	Results	35
Chapter Five	Discussion	45
Chapter Six	Implications of this Study	56
Chapter Seven	Future Research	58
References		59
Appendix I	Ethics Approval Certificate	65
Appendix II	Direct Age-adjustment of Prevalence Rates	67

List of Tables

Table 1.	Diabetes Prevalence Rates for Aboriginal Populations in Canada, West to East	12
Table 2.	Age and Gender Breakdown of the Bella Coola Valley Based on the 2001 Census (Statistics Canada, 2001)	26
Table 3.	Number of People Living On and Off Reserve in the Bella Coola Valley, 2001 Census (Statistics Canada, 2001)	28
Table 4.	Age and Gender Breakdown of the Bella Coola Valley Study Population	31
Table 5.	Comparison of 2001 Census Population and Study Population Broken Down by Age and Gender, for the Bella Coola Valley	32
Table 6.	Summary of the Characteristics of the Adult Study Population	35
Table 7.	Odds Ratios (OR), p Values and 95% Confidence Intervals (CI) for Diabetes from Univariate and Multivariate Logistic Regression Models	42

List of Figures

Figure 1.	Map of British Columbia highlighting the locations of Bella Coola, Williams Lake and Vancouver.	24
Figure 2.	Detailed map of the Bella Coola Valley.	25
Figure 3.	Map of the Central Coast Regional District Electoral Areas. Areas C, D, and E were used to calculate the census population for the Bella Coola Valley.	27
Figure 4.	The prevalence of type 2 diabetes in aboriginal and non-aboriginal males based on age.	37
Figure 5.	The prevalence of type 2 diabetes in aboriginal and non-aboriginal females based on age.	37
Figure 6.	Prevalence rates of type 2 diabetes among aboriginal and non-aboriginal adults based on weight (kg).	39
Figure 7.	Prevalence rates of type 2 diabetes among aboriginal and non-aboriginal adults based on body mass index (kg/m^2).	40

Acknowledgements

I wish to acknowledge several people for their support and guidance in completing this thesis. Dr. Harvey Thommasen for the time and care he put into developing the dataset for this thesis, and the continued support he provided me throughout the process of developing my thesis; Don Voaklander for his expertise in epidemiological studies; Sylvia Barton for her attention to detail; and Amy MacArthur, Research Coordinator for the UBC Department of Family Practice, for her help with my understanding of the statistical analysis of the data.

I would like to acknowledge and thank the people of the Bella Coola Valley for allowing this research to be conducted and for taking an active role in improving the health of their community.

I wish to acknowledge the support I have received through the Western Regional Training Centre for Health Services Research. In addition to financial support, the opportunities that they have provided through workshops, networking and a field placement have given me experiences and skills that could not be gained elsewhere.

Finally, I would like to acknowledge the support of my family and friends. To my parents, who instilled in me the desire to learn and provided me with unconditional love and support. To Jared, who loved me enough to force me to stop procrastinating and actually get on with the business of writing this thesis, and to my friends, who were always there for me whether it was to bounce ideas off them or just to escape the frustrations that inevitably come with writing a Master's thesis.

Chapter One

Introduction

Type 2 diabetes has gone from being nearly nonexistent in the North American native population in 1940 to almost epidemic proportions 50 years later (Evers, McCracken, Antone, & Deagle, 1987; Pioro, Dyck, & Gillis, 1996). As the traditional lifestyle of many aboriginal groups is being abandoned in favour of a more "modern" lifestyle, the incidence of chronic disease is increasing and is becoming one of the major health concerns for aboriginal people. The change in diet and decrease in activity that comes along with the "modern" lifestyle are two of the major factors many researchers feel contribute to the rapid increase in the prevalence of type 2 diabetes in aboriginal populations (Brassard, Robinson, & Lavallee, 1993). Type 2 diabetes is of particular concern to aboriginal people because of the earlier age of onset, the greater severity at diagnosis and the higher rate of complications seen in this population (Health Canada, 2000).

In the general population, if diabetes is diagnosed in children and/or adolescents it is primarily type 1 diabetes, an autoimmune disorder in which the pancreas produces little or no insulin (Health Canada, 2002). It has been determined that within aboriginal populations type 1 diabetes is very rare, however, the diagnosis of type 2 diabetes among children and adolescents is becoming increasingly more common (First Nations and Inuit Health Branch, 2003; Young, 1994). The resulting longer duration of diabetes in these people dramatically increases the likelihood that they will develop complications earlier in life (Young et al., 2002). This not only places an increased burden on the individual, but also results in more strain on an already taxed health care system. The earlier age at onset also means that there are a greater proportion of aboriginal women of childbearing age who are diabetic. This is of concern given the link between maternal diabetes and the risk of subsequent development of type 2 diabetes in the offspring, starting a vicious cycle of type 2 diabetes (Dabelea, Knowler, & Pettitt, 2000).

The greater severity at diagnosis seen among aboriginal diabetics is often the result of late detection or diagnosis of diabetes. It has been reported that aboriginal people seek medical attention less frequently than the general Canadian population. For example, 67% of North American Indians saw a General Practitioner at least once in the previous year compared to the general population average of 82%, according to the 1991 Aboriginal Peoples Survey (Health Canada, 2000). This lack of contact with medical professionals combined with the fact that the symptoms of diabetes can be very subtle and easily overlooked has led to the potential for greater severity of diabetes at diagnosis. Aboriginal people also experience high rates of complications associated with diabetes (Health Canada, 2002). While all people with diabetes are at risk for developing complications, studies have found that aboriginal people are more likely to develop complications than the general diabetic population. For example, in Manitoba it was found that an aboriginal person was twelve times more likely to develop diabetic nephropathy than a non-aboriginal person (Health Canada, 2000). Similarly, aboriginal diabetics experience a higher rate of mortality from diabetes than do the non-aboriginal diabetics (Young, 1994).

According to a report published by Health Canada (2000) the prevalence rate of diabetes among the First Nations people in Canada is 6.4%, more than double the rate for the general population of Canada (3.1%). A higher rate was seen in First Nations people living on-reserve as opposed to those living off (8.5% vs. 5.3%). All of these rates are based on the responses to the 1991 Aboriginal Peoples Survey. While the prevalence rate of diabetes is higher in the aboriginal population overall, it is important to note that there is considerable regional variation. A study conducted by Young, Szathmary, Evers and Wheatley (1990) showed that the prevalence rates of diabetes varied greatly among the provinces and territories, with the Atlantic provinces and Ontario having the highest rates, at 8.7% and 7.6%, respectively, while British Columbia, the Yukon and Northwest Territories had the lowest, at 1.6%, 1.2% and 0.8% respectively. This observed trend in the prevalence rates indicates a west-east gradient, with the prevalence rate of diabetes increasing as one moves from western to eastern provinces. This same study, in addition to others, has also pointed towards a north-south gradient, with the prevalence of diabetes increasing towards the south (Brassard et al., 1993; Delisle & Ekoe, 1993). One possible explanation for this trend is that the southern parts of most provinces are generally more urbanized and therefore, it is more likely that the aboriginal people living in these areas would have adopted a more "modern lifestyle" (Health Canada, 2000).

Given the high prevalence of diabetes seen in the eastern provinces' aboriginal populations, it has been these provinces that have been studied most extensively. By comparison the prevalence rate of diabetes in the various aboriginal groups in British Columbia has not been extensively studied. For this reason, the focus of the present study is to determine the prevalence rate of diabetes among a coastal aboriginal population in British Columbia, and to add this knowledge to the body of literature of the prevalence of diabetes among aboriginal populations across Canada.

Chapter Two

Literature Review

To fully understand the prevalence of diabetes and the impact that prevalence has on a population, the full extent of the disease, and the associated burden of illness, needs to be explored. It is only within this context that the importance of measuring the prevalence of diabetes in a population becomes apparent. The first step is to generally understand diabetes, the different types, the risk factors, and the complications. Secondly, this knowledge can be explored within the context of aboriginal populations, noting similarities and differences.

Diabetes Mellitus

Diabetes mellitus is a chronic disease that results from the body's inability to produce and/or use insulin properly. Insulin is a hormone that is required by the body to convert glucose into energy (Health Canada, 2002). Diabetes mellitus commonly manifests itself in three different forms: type 1, type 2, and gestational. Type 1 and type 2 are both chronic conditions, though they differ in their pathogenesis, whereas gestational diabetes is a temporary condition that occurs during pregnancy for some women. In addition to these types, diabetes can also develop as a result of genetic defects in insulin action or pancreatic β cell function. Patients born with these sorts of genetic defects typically present early in life (e.g. before age 25 years), are non-ketotic, and respond to oral hypoglycemic medications. These conditions have been called mature-onset diabetes of the young. Diabetes can also develop as a secondary condition to diseases or disorders of the pancreas such as pancreatitis, cancer, and other metabolic disorders, trauma or infection (Meltzer et al., 1998).

Less than ten percent of all people with diabetes have type 1 diabetes, which occurs when the body is unable to produce insulin. Over ninety percent of people with diabetes have type 2 diabetes, which occurs when the body cannot produce sufficient insulin and/or is unable to effectively use the insulin produced. Unlike type 1 diabetes, which is dependent on daily injections of insulin, type 2 diabetes can often be controlled through diet and exercise, sometimes with the aid oral medications and/or insulin (Canadian Diabetes Association, 2000). Type 2 diabetes is the focus of this study, and therefore much of the subsequent information will pertain primarily to type 2 diabetes.

In addition to the three types of diabetes, there are two other conditions, often referred to as pre-diabetic conditions, which are important to consider. Impaired fasting glucose is a condition where the fasting blood glucose level is higher than normal, but does not reach the threshold required for a diagnosis of diabetes (American Diabetes Association, 2003). According to Canadian clinical practice guidelines for diabetes (Meltzer et al., 1998) a fasting blood glucose level of between 6.1 mmol/L and 6.9 mmol/L equates impaired fasting glucose. Impaired glucose tolerance is a similar condition, however it results from higher than normal blood glucose levels, 7.8 mmol/L to 11.0 mmol/L, 2 hours after a 75 g glucose load (Meltzer et al., 1998). Both of these conditions place individuals at a higher risk for developing type 2 diabetes, as well as cardiovascular disease (American Diabetes Association, 2002; Meltzer et al., 1998).

<u>Prevalence</u>

According to a report issued by Health Canada (2002), 4.8% of Canadians, 20 years of age and older, had diabetes mellitus in 1998/99. The same report showed that the prevalence of diabetes increases with age and that men generally had a higher prevalence of diabetes than women. In British Columbia, the prevalence rate is approximately 4.9%, almost equivalent to the rate for Canada as a whole (Diabetes Working Group, 2002). There is considerable agreement among those who study diabetes that the prevalence of the disease is on the rise, and if left unchecked will continue to rise. In the United States the age-adjusted prevalence rate of diabetes has almost doubled in 20 years, from 2.77% in 1980 to 4.48% in 2000 (National Center for Chronic Disease Prevention and Health Promotion, 2003). In British Columbia, it is estimated that the prevalence of diabetes will reach 7.1% by the year 2010 (Diabetes Working Group, 2002).

There have been several reasons postulated as to why there is such a marked increase in the prevalence of diabetes. The primary reasons include the fact that the population as a whole is getting older, and the prevalence of diabetes generally increasing with age (Health Canada, 2002). Another key reason for the dramatic increase in the prevalence of diabetes is the parallel increase in the prevalence of obesity, a known risk factor for type 2 diabetes (Choi & Shi, 2001; Diabetes Working Group, 2002; Sheard, 2003). There is one caveat to keep in mind when considering the increase in the prevalence of diabetes. The diagnostic criteria for diabetes were changed in the late 1990's when the fasting plasma glucose value for diagnosis was decreased to 7.0 mmol/L from 7.8 mmol/L. Therefore, more people with diabetes are being identified (Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2002; Meltzer et al., 1998). This change should improve the accuracy of the prevalence rates by decreasing the number of diabetics who go undiagnosed. It is estimated that in Canada as many as one third of all people with diabetes are undiagnosed (Health Canada, 2002).

Risk Factors

There has been substantial research done on the risk factors associated with type 2 diabetes. While many risk factors have been examined, there is consensus among the research community that obesity, physical inactivity, age, race and a family history of diabetes, constitute the major risk factors. It is important to note that none of these risk factors work in isolation, but rather it is the interrelationship of these factors that increases the risk of developing diabetes. The more risk factors that an individual possesses, the greater the risk for developing diabetes (Fletcher, Gulanick, & Lamendola, 2002).

Obesity is the most recognized risk factor for developing type 2 diabetes. Almost every study that investigates the risk factors for type 2 diabetes, identifies obesity, especially abdominal adiposity, or central obesity, as one of the major risk factors (Fletcher et al., 2002). When reviewing the literature on obesity, and the associated risk for the development of type 2 diabetes, it is important to note the definition of overweight and/or obese used. Different studies use varying body mass index (BMI) values to represent either overweight or obese individuals. For example, the World Health Organization defines overweight as having a BMI of over 25 kg/m^2 and obese as having a BMI of over 30 kg/m^2 (Puska, Nishida, & Porter, 2003). Another study uses a BMI of greater than 27 kg/m^2 to signify being overweight and a BMI of between 25 kg/m^2 and 27 kg/m^2 as having some excessive weight (Choi & Shi, 2001). These distinctions become quite important when comparing the results of different studies.

In a report by Health Canada (2002), it was determined that diabetes is more common among overweight (BMI $\geq$ 25 kg/m^2) individuals and that the tendency to be overweight increases with age. Another study, using data from the National Population Health Survey in

Canada, found that the prevalence of diabetes increases with increasing body mass index. The calculated odds ratio for overweight (BMI > 27 kg/m^2) individuals was 3.86, while for individuals with only some excessive weight (BMI 25 – 27 kg/m^2) the odds ratio was 1.60 (Choi & Shi, 2001).

Another risk factor closely associated with obesity, and in turn the development of type 2 diabetes, is physical inactivity. With the shift to an increasingly sedentary lifestyle the proportion of individuals who are participating in a less than optimal level of physical activity is increasing. It has been noted that more women than men reported physical inactivity in Canada in 1998/99 and that physical inactivity appeared to increase with age. Approximately 65% of individuals with self-reported diabetes also reported being physically inactive (Health Canada, 2002). In a study by Choi and Shi (2001) investigating the risk factors associated with diabetes, the authors looked specifically at the correlation between energy expenditure (i.e. the amount of physical activity) and the prevalence of diabetes. They discovered that the prevalence of diabetes increased as the energy expenditure decreased. For example, inactive males had a diabetes prevalence rate of 4.0%, while active males had a prevalence rate of only 2.6%. A similar result was seen with females.

When examining the prevalence rates of diabetes, a clear trend of the rate increasing with age can be seen in almost any population (Choi & Shi, 2001; Health Canada, 2002; Zimmet, 1982). Type 2 diabetes was previously known as ‘adult-onset’ diabetes, given that individuals generally developed the disease later in life. In fact the age of 45 years was used as an important cut-off when looking at the prevalence of type 2 diabetes, however, in recent years the prevalence of this type of diabetes has been rapidly increasing in the younger age groups (e.g. 30 – 39 years) (Fletcher et al., 2002).

Various studies have shown that different ethnic groups have varying prevalences of diabetes within their populations. For example, minorities in the United States experience a diabetes prevalence rate that is two to six times higher than that for Caucasians (Fletcher et al., 2002). It has been proposed that certain ethnic groups have a genetic predisposition to diabetes that is uncovered by exposure to particular environmental factors (Arslanian, 2002). This theory will be examined further within the context of diabetes and aboriginal populations.

Supplementary to the role genetics play in the predisposition of certain ethnic groups to diabetes, genetics also predisposes some individuals to diabetes if they have a family history of the disease. It has been determined that type 2 diabetes is an inherited condition that is expressed under certain environmental factors. People who have a single parent with diabetes have a 3.5 fold greater risk of developing diabetes than those who have no parents with the disease; with two diabetic parents the risk increases to 6 fold (Fletcher et al., 2002). In a study of type 2 diabetes in children, it was discovered that of the Mexican-American children with diabetes, 80% had a first degree relative with the disease. For Black children with diabetes, 95% had a family history of diabetes (Arslanian, 2002).

Complications

Many of the risk factors associated with developing diabetes are also associated with the development of a variety of complications in people with diabetes. These complications are often related to high blood glucose levels and an extended duration of diabetes. They can affect all parts of the body and range from microvascular to macrovascular in nature. Microvascular complications arise from damage to small blood vessels that result in a decrease in blood circulation. Some examples of microvascular complications include retinopathy, nephropathy and periodontal disease. Macrovascular complications are similar to microvascular, except that it is the larger blood vessels that are damaged. This results in outcomes such as cardiovascular disease, cerebrovascular disease, stroke, ischemic heart disease and lower limb amputation (Health Canada, 2002). These complications can have a devastating effect on the person's life, affecting both its quality and longevity.

Given the overwhelming prevalence of diabetes, and the potentially devastating consequences of the disease, appropriate management is crucial. It is generally agreed upon that appropriate management of diabetes can prevent, or at the very least delay the onset of, many of the complications associated with the disease (Health Canada, 2002). In addition to maintaining a healthy lifestyle, including diet and exercise, maintaining optimal control over blood glucose levels, blood pressure, and blood lipid composition has proven to be effective in staving off complications and improving the quality of life for someone with diabetes (Vaaler, 2000).

Diabetes and Aboriginal Populations

There is considerable consensus among the literature that prior to 1940, type 2 diabetes was nearly non-existent in aboriginal people (Evers et al., 1987; Hernandez, Antone, & Cornelius, 1999; Macaulay, Montour, & Adelson, 1988; Young, McIntyre, Dooley, & Rodriguez, 1985). Since the end of the Second World War, there has been an explosion in the number of cases of diabetes in aboriginal populations to the point where it is considered an epidemic in many tribes. The prevalence rates of type 2 diabetes vary with different aboriginal groups and their geographic location, but overall the prevalence rates for aboriginal populations are generally higher than non-aboriginal populations.

Prevalence

The prevalence of diabetes among aboriginal people has been extensively studied in the United States, particularly the Pima Indians in Arizona where diabetes is prevalent in almost 50% of the adult population (Benyshek, Martin, & Johnston, 2001). A study conducted using the Indian Health Services national outpatient database estimated the age-adjusted prevalence of diabetes among the Native Americans and Alaska Natives in 1997 to be 8.0% (Burrows & Geiss, 2000). An analysis of the prevalence data broken down by age and sex showed that the prevalence rate of diabetes increases with age and is higher among women than men. However, from the years 1990 to 1997, men experienced a greater increase in their prevalence of diabetes than women, despite the fact that women have a higher overall prevalence. One disturbing observation in this study was the fact that for people under the age of 45 years, the increase in the prevalence rate of diabetes was ten times greater for Native Americans than for the general United States population. As type 2 diabetes has traditionally primarily affected older people, this increasing trend of an earlier age of diagnosis is cause for concern. The increased duration of diabetes for these individuals puts them at a greater risk of developing complications.

While the Native Americans in the United States have been the subject of much research over the last 40 years or so, studies of the aboriginal populations in Canada were not done extensively until around the 1980's. Since then a number of studies have been conducted, especially of the aboriginal groups in Ontario and Quebec. Fewer studies have been done on the aboriginal groups in British Columbia, though more are emerging. Table 1 provides a summary of the various prevalence rates reported for different aboriginal groups across Canada.

Table 1. Diabetes Prevalence Rates for Aboriginal Populations in Canada, West to East.

Location	**Aboriginal Group**	**Age Group**	**Type of Prevalence (year)**	**Prevalence Rate**	**Reference**
British Columbia	On-reserve First Nations	All ages	Crude prevalence (1997)	2.6%	(Johnson, Martin, & Sarin, 2002)
British Columbia	On-reserve First Nations	35 years +	Crude prevalence (1997)	7.2%	(Johnson et al., 2002)
British Columbia	All First Nations	All ages	Crude prevalence (1995)	2.2%	(Martin & Yidegiligne, 1998)
British Columbia	All First Nations	35 years +	Crude prevalence (1995)	6.3%	(Martin & Yidegiligne, 1998)
British Columbia	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	1.6%	(Young, Szathmary et al., 1990)
Alberta	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	5.1%	(Young, Szathmary et al., 1990)
Saskatchewan	All First Nations groups in the province	20 years +	Direct age-standardization (1990)	9.7%	(Pioro et al., 1996)
Saskatchewan	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	3.9%	(Young, Szathmary et al., 1990)
Manitoba	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	5.7%	(Young, Szathmary et al., 1990)
Sandy Lake, Ontario	Ojibwa, Cree	10 years +	Direct age-standardization (1991)	26.1%	(Harris et al., 2003)
Southwestern Ontario	Oneida, Chippewa, Muncey	5 years +	Direct age-standardization (1985)	14.7%	(Evers et al., 1987)
Moose Factory, Ontario	Cree	15 years +	Direct age-standardization (1998)	13.1%	(Maberley, King, & Cruess, 2000)

Table 1. Continued

Location	Aboriginal Group	Age Group	Type of Prevalence (year)	Prevalence Rate	Reference
Moose Factory, Ontario	Cree	All ages	Direct age-standardization (1998)	10.3%	(Maberley et al., 2000)
Ontario	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	7.6%	(Young, Szathmary et al., 1990)
James Bay, Quebec	Cree	20 years +	Direct age-standardization (1989)	6.6%	(Brassard et al., 1993)
Lac Simon, Quebec	Algonquin	15 years +	Age-standardization (1989)	19%	(Delisle & Ekoe, 1993)
River Desert, Quebec	Algonquin	15 years +	Age-standardization (1989)	9%	(Delisle & Ekoe, 1993)
Quebec	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	4.8%	(Young, Szathmary et al., 1990)
Atlantic Region	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	8.7%	(Young, Szathmary et al., 1990)
Northwest Territories	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	0.8%	(Young, Szathmary et al., 1990)
Northwest Territories	Inuit	All ages	Direct age-standardization (1987)	0.4%	(Young, Szathmary et al., 1990)
Yukon Territory	On-reserve Aboriginals	All ages	Direct age-standardization (1987)	1.2%	(Young, Szathmary et al., 1990)

As seen in Table 1, the prevalence rates of diabetes vary considerably between different aboriginal groups across Canada. The Northwest Territories and the Yukon Territory have the lowest prevalence rates of diabetes, while Ontario has some of the highest rates. The overall prevalence rates of diabetes reported for British Columbia are quite low, comparatively. However when just those over the age of 35 years are looked at, the prevalence rates increase substantially, indicating that the prevalence of diabetes is of considerable concern among the aboriginal groups of British Columbia as well.

Prevalence Trends

There are three major trends seen in the diabetes prevalence studies done with aboriginal groups. The first major trend is that the prevalence of diabetes increases with age (Harris et al., 2003; Jorgensen et al., 2002). A study of Native Americans and Alaska Natives found that the prevalence of diabetes increased from 0.2% in the under 20 years age group to a peak of 22.8% in the greater than or equal to 65 years age group (Burrows & Geiss, 2000). This trend is not exclusive to aboriginal groups, but rather it is something that is generally known about type 2 diabetes. However, aboriginal populations have a greater proportion of their population being diagnosed with type 2 diabetes at a younger age than their Caucasian counterparts. In a study comparing the Indian and Caucasian populations of Southwestern Ontario, those Indian individuals aged 25 to 34 years had a diabetes prevalence rate of 4.1%, while Caucasians in the same age group had a prevalence rate of only 0.4%. The difference between the two populations becomes even more drastic at the 35 to 44 years age group where the diabetes prevalence rates for the Indian population and Caucasian population are 15.5% and 0.7%, respectively (Evers et al., 1987).

The second major trend seen in the prevalence of diabetes among aboriginal populations is that the prevalence is generally higher among women than men (Brassard et al., 1993; Delisle & Ekoe, 1993; Harris et al., 2003; Johnson et al., 2002; Pioro et al., 1996; Young, Szathmary et al., 1990). Burrows and Geiss (2000) noted that not only did women have a higher prevalence of diabetes than men, but the prevalence rate was actually 1.4 times higher. In a study of the Cree of Western James Bay, 64% of the people with diabetes in Moose Factory, Ontario were women (Maberley et al., 2000).

The third and final major trend identified in many of the studies reviewed involves the prevalence of diabetes being related to the geographic location of the population. There are two related facets to this trend, a north-south gradient and the effect of the relative isolation and/or rurality of the community (Young, Szathmary et al., 1990). Brassard, Robinson and Lavallée (1993) examined the prevalence of diabetes in eight Cree villages along James Bay in Quebec. The northernmost community had a low prevalence rate of 1.9% while the southernmost community had a considerably higher prevalence rate of 9.0%. The same north-south gradient was seen in Saskatchewan with only 1.7% of on-reserve First Nations people living in the northern part of the province having diabetes, while 3.7% of the First Nations population living in the south have the disease (Pioro et al., 1996). In British Columbia, the prevalence of diabetes in the south, when considering all ages, is more than one and a half times the prevalence in the north (3.0% and 1.8%, respectively) (Johnson et al., 2002). Another study done in British Columbia that broke down the geographic location of the First Nations groups into four distinct locations (South Mainland, Vancouver Island, Northwest and Northeast) again found the similar north-south gradient. It was also discovered that while the northeast zone had the lowest prevalence rate, that rate had also increased three fold between 1987 to 1995, from 0.5% to 1.5% (Martin & Yidegiligne, 1998). Related to the issue of the north-south gradient, is the distinction between the prevalence of diabetes in communities classified as urban, rural or remote. Brassard, Robinson and Lavallée (1993) categorized the eight communities in their study based on accessibility. Six communities where deemed to be remote given that they are primarily accessible by air with very limited road access. The other two communities were classified as rural because they could be more easily accessed by roads. The study found that the diabetes prevalence rates were significantly higher in the two rural communities than the six remote communities (8.8% and 3.4%, respectively). Young, Szathmary, Evers and Wheatley (1990) defined urban as a community within 100 km by road of a Census Metropolitan Area, rural as a community located further than 100 km from a Census Metropolitan Area and accessible by road and/or rail, and remote as a community also further than 100 km from a Census Metropolitan Area but only accessible by air or water. Generally, the prevalence rate of diabetes was highest in the urban communities and lowest in the remote communities.

Theories Behind the High Prevalence of Type 2 Diabetes in Aboriginal Populations

Thrifty Genotype Theory

The thrifty genotype theory is the most commonly cited theory when trying to reason why the prevalence of type 2 diabetes is so high in some indigenous populations (Lieberman, 2003; Schulz, 1999). James V. Neel first introduced the theory in the early 1960's in relation to the high prevalence of diabetes seen in Native American populations. He postulated that individuals with the ability to store energy when food was abundant and effectively use that stored energy during times of food deprivation, had a selective advantage during the time when the feast-and-famine cycle was common (Neel, 1962). Once the feast-and-famine cycle was no longer an issue for these populations, this adaptive genotype that had once been advantageous, was now detrimental to the health and well being of these people. It is important to note that the thrifty genotype alone does not lead to the development of type 2 diabetes, but rather it is this genotype in conjunction with a change in lifestyle that seems to lead to the development of type 2 diabetes. A study conducted by Schulz (1999) illustrates the relative contribution of genetics and lifestyle to the development of type 2 diabetes among the Pima Indians. The Pima Indians of Arizona have the highest prevalence rate of type 2 diabetes reported, with reported rates ranging from 35 to 50% (Benyshek et al., 2001; Wendorf, 1992; Zimmet, 1982). Schulz (1999) identified a genetically-related population of Pima Indians living in an isolated community in Mexico where they continue to live a predominantly traditional lifestyle. A comparison of these two groups was used to determine the relative impact genetics and lifestyle have on the development of type 2 diabetes. The Pima Indians of Arizona were forced to adopt a western lifestyle relatively quickly after circumstances made continuing their traditional way of life, primarily associated with agriculture, impossible. This change in lifestyle resulted in a diet that consisted of considerably more fat and less dietary fiber than their traditional diet, and a severe reduction in their activity level. In comparison, the Pima Indians of Mexico still maintain their traditional lifestyle, which involves growing their own food and working labor-intensive jobs. Their diet consists primarily of beans, corn and wheat tortillas, potatoes and inexpensive soups, and the consumption of animal products is rare. The Mexican Pima Indians are incredibly physically active with the men working labouriously for approximately 48 hours per week, of which 40 hours are spent doing hard labour. The women, while rarely working outside of the home, still spend approximately 91 hours per week doing labourious household tasks, since there is no electricity or running water. These vast differences in lifestyle have correlated with significant differences in the prevalence of type 2 diabetes. In the study populations it was found that the prevalence of type 2 diabetes among the Arizona Pima Indians was 38% while among the Mexican Pima Indians it was only 6%. Given the genetic relatedness of the two populations, it stands to reason that lifestyle plays a significant role in the development of type 2 diabetes.

Lieberman (2003), in her discussion of the dietary and modernizing influences on the development of type 2 diabetes, detailed the nutritional transitions that many of the world's populations have gone through during the process of modernization. This transition has been broadly divided into five phases. In the beginning, phase one, hunting and gathering comprised most of the food collection. In phase two, diets exhibit less variety and there is increasing incidence of starvation. This food deprivation led to the advent of agriculture. With the agriculture came fewer periods of famine in phase three and once again the variety of the diet increased with the addition of more fruits, vegetables and animal products. It is in phase four that the major lifestyle shift occurs, involving increased intake of animal fat, sugar, and processed foods, and a reduction in the level of physical activity required to sustain this lifestyle. This phase is currently being experienced by most modern, Western civilizations and is at the point where many populations are developing an increased prevalence of chronic conditions such as obesity and diabetes. The final phase in the nutrition transition involves recognition of the problems created by phase four and an active, conscious attempt to rectify them. This includes behavioural changes, a reduction in the consumption of fat and processed foods, and an increased intake of fruits and vegetables. It also involves the supplementation of physically active leisure activities to compensate for a less physically demanding workload.

This change in lifestyle and the results of the study conducted on the Pima Indians in Arizona and Mexico seem to support the thrifty genotype theory proposed by Neel all those years ago. However, not everyone fully supports this theory. Benyshek, Martin and

Johnston (2001) in their paper entitled, *A Reconsideration of the Origins of the Type 2 Diabetes Epidemic among Native Americans and the Implications for Intervention Policy* point out several problems with the thrifty genotype theory and offer an alternative hypothesis to the high prevalence of type 2 diabetes among Native Americans. Some of the issues raised revolve around the genetic studies conducted in an attempt to prove the thrifty genotype theory. There is concern surrounding methodological bias and the resulting conclusions drawn from these studies. Secondly, the authors point out the inherent leap that some researchers are making when generalizing the results of genetic studies on the very rare forms of diabetes (e.g. maturity onset diabetes of the young) to the more common forms of diabetes, namely type 1 and type 2 diabetes. Finally, Benyshek et al. state that there appears to be little evidence that Native Americans went through regular periods of starvation, which is a fundamental argument for the thrifty genotype theory.

An Alternate Hypothesis: The Thrifty Phenotype

A study conducted in England was the basis for a new hypothesis about the origins of the diabetes epidemic among certain populations (Hales et al., 1991). Rather than focusing on the genotypic origin of diabetes, this hypothesis focuses on the phenotypic origin. The aim of the study was to investigate whether there was a relationship between fetal growth, specifically reduced fetal growth, and the development of type 2 diabetes. Using birth weight and weight at age 1 year data for 468 men born in east Hertfordshire, England between 1920 and 1930, the association between these weights and the subsequent development of type 2 diabetes later in life was examined. The authors discovered that adult men with impaired glucose tolerance and type 2 diabetes were more likely to have a lower birth weight and reduced weight gain during infancy. For example, of the men who had a birth weight of less than or equal to 5.5 pounds (or 2495 grams), which is the definition of low birth weight, 30 percent had impaired glucose tolerance and 10 percent had type 2 diabetes. Conversely, the percentage of men with impaired glucose tolerance and type 2 diabetes, whose birth weights were 9.5 pounds (or 4309 grams), was 4 percent and 9 percent, respectively. From these results, the authors proposed that malnutrition during critical periods of the pregnancy and, therefore, fetal growth and development, could prevent the proper development of β cell function. β cells are a key component in the production of insulin, as well as in the development of diabetes. It is thought that this change in the development of β cells is the result of the fetus adapting to malnutrition in utero, and that physiologic changes made during fetal development result in more permanent changes in the body than those made during adulthood (Barker, 1999). While this adaptation increases the survival of the fetus during times of malnutrition, it becomes a liability for the individual in times of food abundance.

On the flip side of the low birth weight association is the association between high birth weight, or macrosomia, and the subsequent development of type 2 diabetes. Macrosomia is often the result of gestational diabetes or maternal diabetic status, which in and of itself increases the risk of the offspring developing type 2 diabetes. Rich-Edwards et al. (1999), in their study of a cohort of American women, found a U-shaped association between birth weight and type 2 diabetes, with both women of low birth weight and high birth weight having an increased risk of developing type 2 diabetes. However, when the data was adjusted to consider the presence of gestational diabetes or maternal diabetic status, the U-shaped trend was replaced by an inverse relationship seen across all birth weights. A study conducted with the Registered Indians in Saskatchewan noted the association between high birth weight and type 2 diabetes, however, no significant association between low birth weight and type 2 diabetes was found (Dyck, Klomp, & Tan, 2001). The authors recognized that the high prevalence of maternal obesity, gestational diabetes and maternal diabetes could account for the relationship between high birth weight and type 2 diabetes.

Both the thrifty genotype hypothesis and the thrifty phenotype hypothesis have their strengths and weaknesses. While neither hypothesis has shown a definitive causal relationship that can be explicitly proven, both have stimulated considerable research and have a certain degree of plausibility. The quest to better understand the origins of the diabetes epidemic seen in many populations has, as a result, focused attention on the problem of diabetes and the need for more effective prevention and management strategies.

Research Questions

The purpose of this thesis is to answer the following questions about diabetes in the Bella Coola Valley:

1. What is the prevalence of diabetes among the aboriginal and non-aboriginal people living in the Bella Coola Valley?
2. How do these prevalence rates compare to the rates reported in the literature for other aboriginal groups?
3. Are age, weight, body mass index, gender and aboriginal status significant risk factors for developing diabetes?

Chapter Three

Methods

Research Design

This study is a retrospective population-based cross-sectional study. Cross-sectional studies are the most common type of study done when examining the prevalence of disease. A key feature to the cross-sectional study is that it measures both the exposure status and the disease status at the same time. For this reason, one of the limitations to this type of study is that it is generally not possible to determine whether or not the exposure preceded the development of the disease or came as a result of the disease (Hennekens & Buring, 1987). However, this limitation is diminished when looking at factors that are not changed by the disease (Kelsey, Whittemore, Evans, & Thompson, 1996). In the context of this study, those risk factors include age, gender and aboriginal status.

Study Community

The community chosen for study was the Bella Coola Valley. Located on the central coast of British Columbia, the Bella Coola Valley is one of the most isolated rural communities in British Columbia (Figure 1, 2). Nestled deep in the Coast Mountains, the small town of Bella Coola is situated next to the Bella Coola River estuary, where the river meets Burke Channel, the only port with access to inland British Columbia between Vancouver and Prince Rupert. The main access to the Bella Coola Valley is by Highway 20, an approximately 450 km stretch of highway that links the Bella Coola Valley with Williams Lake in interior British Columbia. While this is a very scenic route to travel, it is also a challenging drive particularly in the area just east of Bella Coola known as The Hill. This area consists of a "steep, narrow road with sharp hairpin turns and two major switchbacks, as the highway descends from the Chilcotin Plateau" (Bella Coola Valley Tourism, 2003). In addition to road access, Bella Coola can also be accessed by air and water. There is a daily flight between Bella Coola and Vancouver all year round, with an additional flight offered during the summer. BC Ferries operates a Discovery Coast Passage route, which links Bella Coola to Port Hardy on Vancouver Island (Bella Coola Valley Tourism, 2003).

The economy of the Bella Coola Valley is primarily dependent upon natural resources. Commercial salmon fishing and forestry have been the major contributors to the local economy; however, with the cutbacks seen province-wide in both of these areas, tourism is becoming an increasingly important component (Central Coast Economic Development Commission, 1990). The unemployment rate in 2002 for the Central Coast Regional District, of which Bella Coola is the major centre, was 8.0%, substantially higher than the provincial average of only 3.6% (BC Stats, 2002).

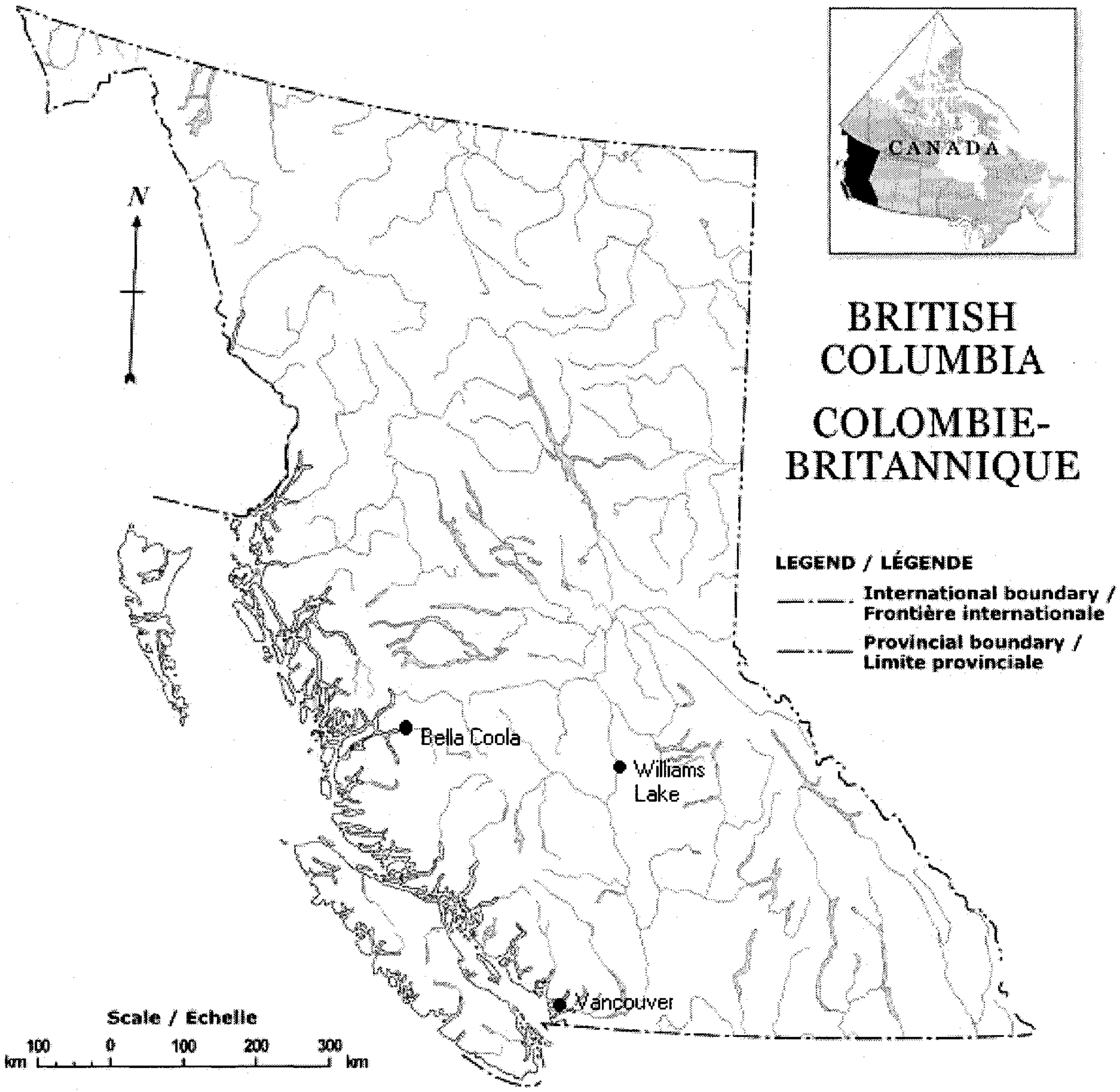

Figure 1. Map of British Columbia highlighting the locations of Bella Coola, Williams Lake and Vancouver.

Figure 2. Detailed map of the Bella Coola Valley.

Bella Coola Valley Population

The population of the Bella Coola Valley is approximately 2,260 people according to the 2001 census data. To determine the population of the Bella Coola Valley, and not the larger Central Coast Regional District, the populations of individual Regional District Electoral Areas for the Central Coast (Central Coast C, Central Coast D, and Central Coast E), in addition to the Bella Coola Indian Reserve, were aggregated to get an approximation of the population of the Bella Coola Valley (Figure 3). The age and gender breakdown of the total population of the Bella Coola Valley is provided in Table 2.

Table 2. Age and Gender Breakdown of the Bella Coola Valley based on the 2001 Census (Statistics Canada, 2001).

Age Group	Male	Female
Age 0 – 4	90	65
Age 5 – 14	185	185
Age 15 – 19	85	100
Age 20 – 24	60	50
Age 25 – 44	355	340
Age 45 – 54	190	155
Age 55 – 64	110	90
Age 65 – 74	60	70
Age 75 – 84	25	30
Age 85 and over	10	5
Total	1170	1090

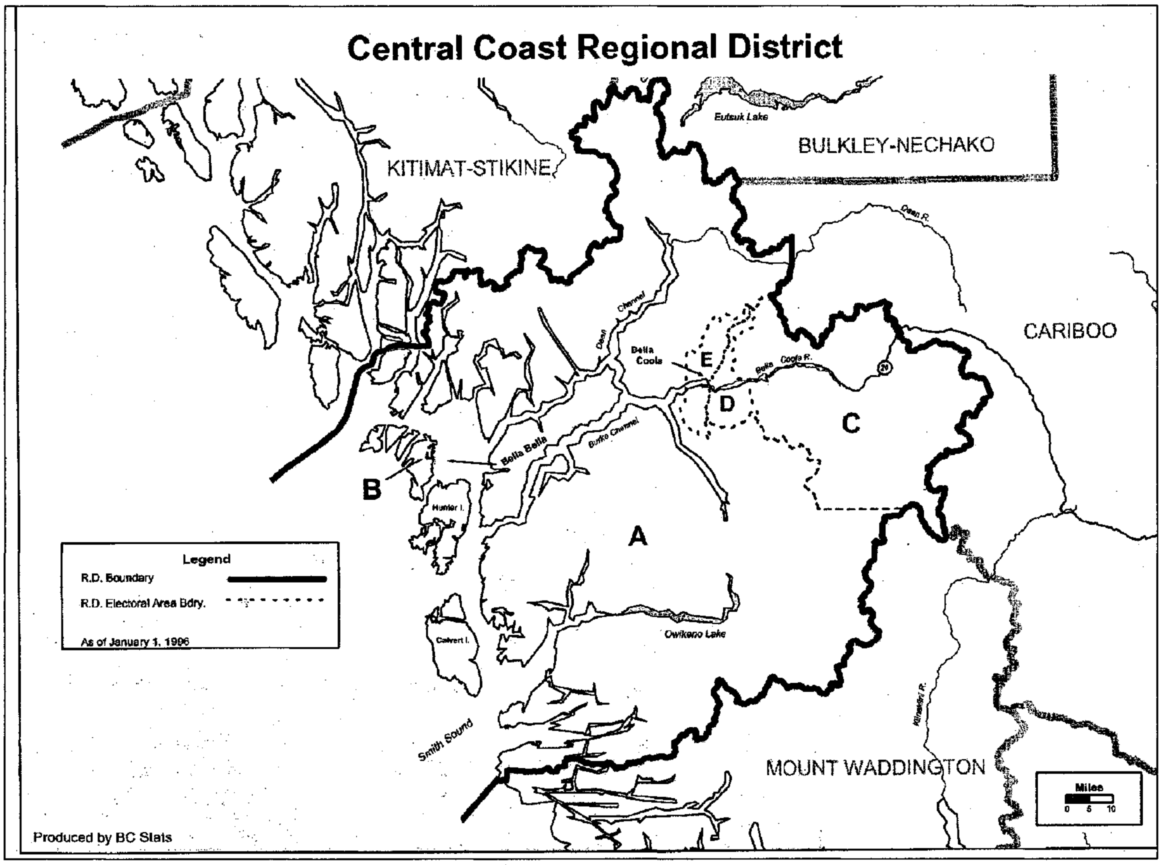

Figure 3. Map of the Central Coast Regional District Electoral Areas. Areas C, D, and E were used to calculate the census population for the Bella Coola Valley.

A significant portion of the population of the Bella Coola Valley is made up of aboriginal people, approximately 44% according to the 2001 census. The majority of these aboriginal people live on the Bella Coola Indian Reserve as indicated in Table 3.

Table 3. Number of People Living On and Off Reserve in the Bella Coola Valley, 2001 Census (Statistics Canada, 2001).

	Living Off Reserve	Living On Reserve
First Nations	135	855
Non-First Nations	1240	55
Total	1375	910

Most of the aboriginal people living in the Bella Coola Valley are of Nuxalk decent. The Nuxalk are part of the Salish language group and have traditionally lived within the Bella Coola Valley and surrounding central coast areas (Thommasen, Loewen, & McInnes, 1995). They were a settled tribe; living in long houses, constructed of wood harvested locally, with often more than one family residing in each of these houses. The villages were built along the Bella Coola River, allowing easy access to the river itself. The Nuxalk were primarily hunters, fishermen, and traders before they came in contact with the Europeans. They hunted deer, mountain goat, moose, grizzly bear, seal, and duck. The large eulachon fish runs provided the sustenance of their trading, as the grease produced from these fish was traded with inland tribes (Central Coast Economic Development Commission, 1990).

Contact with Europeans began in the late 18th century with the arrival of the explorers. By the early 19th century, the Hudson's Bay Company had built forts in the area and had established a regular trade route. This contact led to a change in the Nuxalk culture, with the people now abandoning some of their traditional activities in order to stay closer to the established forts. This regular contact with foreign people, and thereby foreign diseases, made the Nuxalk population very vulnerable. In fact, the smallpox epidemic in 1862 nearly destroyed the native population (Central Coast Economic Development Commission, 1990).

Health Services in the Bella Coola Valley

The only hospital and clinic in the Bella Coola Valley is located within the town of Bella Coola itself. Bella Coola General Hospital, operated by the United Church Health Services, delivers a wide range of health services including surgery and medicine, on both an outpatient and inpatient basis, and 24 hour emergency coverage (Thommasen, Newberry, & Watt, 1999; Vancouver Coastal Health Authority, 2003). In addition, it also has onsite laboratory, x-ray, and physiotherapy services. The hospital and adjacent clinic are served by three physicians and one family practice resident physician (Bella Coola General Hospital, n.d.). On average these physicians see approximately 8,000 clinic visits, 2,500 emergency room visits, and 400 hospital admissions (Gobrial, Mekael, Anderson, Ayers, & Thommasen, 2002).

The isolated nature of Bella Coola, and thereby the Bella Coola General Hospital and adjacent clinic, results in almost everyone who lives in the Bella Coola Valley having either a clinic chart or emergency room record. This makes Bella Coola an ideal location to do this type of population-based study.

Data Collection – The Bella Coola Valley Clinic Population

A retrospective chart review was conducted by Dr. Harvey Thommasen, a Family Physician at the Bella Coola Medical Clinic, of all of the clinic charts. An estimated 560 hours were spent reviewing the approximately 2,700 clinic charts. The criterion for inclusion in this study population was a current address located within the Bella Coola Valley. Therefore, residents of Anahim Lake, Nimpo Lake, Ocean Falls and Bella Bella were excluded from the study population.

After excluding those clinic charts of people who did not currently live within the Bella Coola Valley, 2,377 patients made up the study population. The information collected during the chart review, in addition to address, included age, gender, weight, body mass index, aboriginal status, and presence or absence of diabetes. Age was calculated as of May 2001 based on the patient's birth date. The weight recorded was the most recent on file and the body mass index was calculated for those patients who had both a weight and height value on file. The presence of diabetes was based on a physician diagnosis of the disease, which, in turn, was based on the 1998 clinical practice guidelines for the management of diabetes in Canada (Meltzer et al., 1998).

Aboriginal status for the study population was determined from multiple sources. Aboriginal status for Nuxalk Band members was determined from the 1920, 1979, 1989, and 2001 Nuxalk Band lists, as well as the birth and death vital statistics for the Nuxalk Band members. In consultation with Nuxalk elders, Dr. Harvey Thommasen constructed a comprehensive geneology of the Nuxalk people in the 1990's that was also used to assign aboriginal status to the Nuxalk patients in the study population. There are, however, aboriginal people living in the Bella Coola Valley who are not of Nuxalk decent. These people were identified from a review of their charts; from their response to a survey question asking about aboriginal status; or by asking them directly about their aboriginal ancestry. After aboriginal status was assigned to each patient in the study population by Dr. Harvey Thommasen; a long-time resident and Medical Clinic staff member then reviewed, and verified or questioned, the correctness of the aboriginal status assigned according to the best of that person's knowledge. There were only a few alterations made after consultation with the Medical Clinic staff person. Approximately 47% of the people living in the Bella Coola Valley are of aboriginal decent, according to the aboriginal status assigned to the study population. The 2001 census estimates that approximately 44% of the population of the Bella Coola Valley is of aboriginal decent. Table 4 summarizes the age and sex breakdown of the Bella Coola Valley study population.

Table 4. Age and Gender Breakdown of the Bella Coola Valley Study Population

Age (years)	Total Population	Male	Female
0-4	155	85	70
5-14	367	191	176
15-19	215	103	112
20-24	147	72	75
25-44	686	352	334
45-54	369	202	167
55-64	220	115	105
65-74	141	72	69
75-84	62	25	37
≥ 85	15	7	8
Total	2377	1224	1153

According to the 2001 census data, there are 2,260 people living in the Bella Coola Valley. The estimation of the Bella Coola Valley population, based on the clinic chart review, is 2,377, or 105% of the 2001 census population. For this reason, we are confident that we have captured the entire Bella Coola Valley population. Table 5 compares the age and sex breakdown of the census population to the study population.

Table 5. Comparison of 2001 Census Population and Study Population, Broken Down by Age and Gender, for the Bella Coola Valley.

	Male		Female	
Age (years)	2001 Census Population	Study Population	2001 Census Population	Study Population
0-4	90	85	65	70
5-14	185	191	185	176
15-19	85	103	100	112
20-24	60	72	50	75
25-44	355	352	340	334
45-54	190	202	155	167
55-64	110	115	90	105
65-74	60	72	70	69
75-84	25	25	30	37
≥ 85	10	7	5	8
Total	1170	1224	1090	1153

All of the data was entered into an Excel spreadsheet by Dr. Harvey Thommasen. Once he had confirmed that the data transfer was accurate, all of the identifying pieces of information were removed and replaced with identification numbers. This process was to ensure the confidentiality of the people of the Bella Coola Valley. It was at this point that the dataset became available to be used for analysis in this study.

Ethics Approval

Ethics approval to collect the data related to this study was obtained from the Research Ethics Committee at the University of British Columbia by Dr Harvey Thommasen. Ethics approval to use the data in this particular thesis was obtained from the Research Ethics Board at the University of Northern British Columbia (Appendix I).

Data Analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) for Windows. All analyses were conducted on the total adult study population ($\geq$ 18 years) and for aboriginals and non-aboriginals separately, where appropriate. To answer the research questions, the following analysis strategies were utilized:

What is the prevalence of diabetes among the aboriginal and non-aboriginal people living in the Bella Coola Valley?

The crude prevalence rates of diabetes were calculated through simple frequency tables. The age-adjusted prevalence rates were calculated using the direct method of adjustment with the standard population being a distribution of the aboriginal and non-aboriginal populations combined (Hennekens & Buring, 1987). Prevalence rates were broken down by gender, age groups, weight and body mass index categories.

How do these prevalence rates compare to the rates reported in the literature for other aboriginal groups?

The prevalence rates determined for the Bella Coola Valley aboriginal population were compared to the rates reported for other aboriginal populations with particular attention paid to the prevalence trends observed in the literature and how they compare to the trends observed in the Bella Coola Valley study population.

Are age, weight, body mass index, gender and aboriginal status significant risk factors for developing diabetes?

For the analysis of statistical significance the dependent variable is diabetic status as a dichotomous variable. The difference in prevalence rates based on gender and aboriginal status were evaluated using Pearson's chi-squared. The differences based on age, weight, and body mass index, all continuous variables, were evaluated using ANOVA.

Odds ratios were calculated using logistic regression to determine the predictive power of age, weight, body mass index, gender, and aboriginal status. A univariate analysis was performed on each risk factor. Subsequently, a multivariate analysis was performed. Both weight and body mass index could not be included in the multivariate analysis because they are too highly correlated. Given the large number of body mass index values that were missing from the dataset, weight was chosen for inclusion in the multivariate analysis.

For all of the analyses significance was set at $p \leq 0.05$.

Chapter Four

Results

The characteristics of the study population, divided into aboriginal and non-aboriginal subsets, are summarized in Table 6.

Table 6. Summary of the Characteristics of the Adult Study Population

Characteristic	Aboriginal N (%)	Non-aboriginal N (%)	p Value
Gender			0.810
Male	366 (50.9)	518 (51.5)	
Female	353 (49.1)	488 (48.5)	
Age (years)			0.000
18 – 24.9	140 (19.5)	92 (9.1)	
25 – 34.9	170 (23.6)	143 (14.2)	
35 – 44.9	156 (21.7)	217 (21.6)	
45 – 54.9	129 (17.9)	240 (23.9)	
55 – 64.9	66 (9.2)	154 (15.3)	
≥ 65	58 (8.1)	160 (15.9)	
Weight (kg)[a]			0.182
< 60	65 (9.0)	98 (9.7)	
60 – 69	105 (14.6)	178 (17.7)	
70 – 79	145 (20.2)	200 (19.9)	
80 – 89	148 (20.6)	186 (18.5)	
90 – 99	99 (13.8)	121 (12.0)	
100 – 109	62 (8.6)	75 (7.5)	
≥ 110	58 (8.1)	55 (5.5)	
Body Mass Index (kg/m^2)[b]			0.000
< 25	83 (11.5)	203 (20.2)	
25 – 29.9	139 (19.3)	253 (25.1)	
30 – 34.9	107 (14.9)	126 (12.5)	
35 – 39.9	87 (12.1)	52 (5.2)	
≥ 40	48 (6.7)	23 (2.3)	

[a] Weight data is missing from 130 (7.5) patients [37 (5.1) aboriginal; 93 (9.2) non-aboriginal]
[b] Body mass index data is missing from 604 (35.0) patients [255 (35.5) aboriginal; 349 (34.7) non-aboriginal]

There is a similar gender distribution in both the aboriginal and non-aboriginal populations, with both populations having nearly a 1:1 ratio of males to females. The non-aboriginal population is significantly older than the aboriginal population ($p < 0.001$), with mean ages of 40.28 ± 21.00 years and 29.09 ± 19.51 years, respectively. The non-aboriginal population also has a higher mean weight (70.87 ± 26.31 kg vs. 65.77 ± 30.45 kg) than the aboriginal population, however this difference was not significant. The non-aboriginal population also had a lower mean body mass index (25.92 ± 6.33 kg/m^2 vs. 27.25 ± 8.02 kg/m^2) than the aboriginal population, and this difference was found to be significant ($p < 0.001$). This indicates that the aboriginal population is potentially more overweight than the non-aboriginal population.

The overall crude prevalence of type 2 diabetes was higher in the aboriginal adult population than in the non-aboriginal adult population (9.7% vs. 5.7%). Given the significant differences in the age distributions of the aboriginal and non-aboriginal populations, and the important role that age plays in the prevalence of diabetes, it was important to calculate the age-adjusted prevalence rates for each of the populations. Details of these calculations can be found in Appendix II. The age-adjusted prevalence rates of diabetes for the aboriginal and non-aboriginal populations were 12.5% and 4.8%, respectively. Figures 4 and 5 illustrate the trends in type 2 diabetes prevalence based on age and gender. For each graph, the prevalences in both the aboriginal and non-aboriginal populations are compared. The relationship between aboriginal ancestry and diabetic status was found to be statistically significant ($\chi^2 = 10.183$; $p = 0.001$).

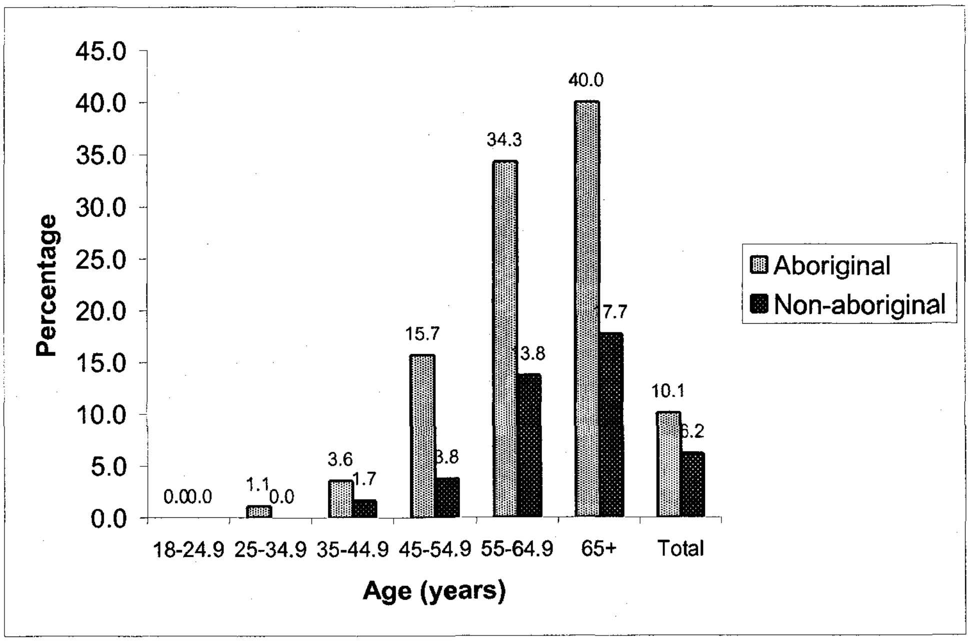

Figure 4. The prevalence of type 2 diabetes in aboriginal and non-aboriginal males based on age.

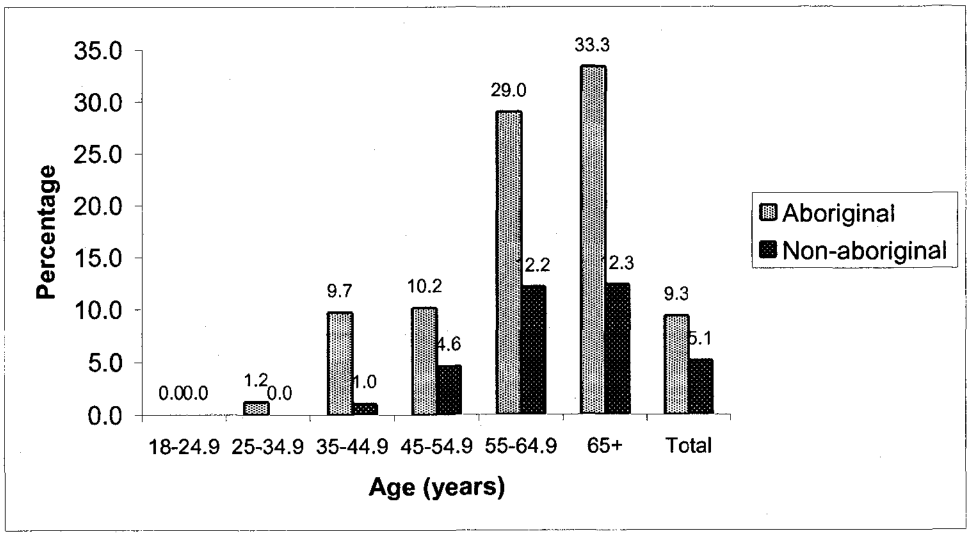

Figure 5. The prevalence of type 2 diabetes in aboriginal and non-aboriginal females based on age.

Aside from the aboriginal population having a consistently higher prevalence rate of diabetes, a trend of the rate increasing with increasing age can also be clearly seen in both males and females. The overall prevalence of diabetes for non-aboriginal males is slightly higher than for non-aboriginal females (6.2% vs. 5.1%). The same is true for the aboriginal population overall (males = 10.1%; females = 9.3%), though aboriginal females aged 35 to 44.9 years have a prevalence rate substantially higher than aboriginal males in the same age group (9.7% vs. 3.6%). Despite the generally higher prevalence rates observed in males, there was no significant relationship found between gender and diabetic status. There was, however, a significant relationship observed between age and diabetic status, in both the aboriginal ($F = 25.98$; $p < 0.001$) and non-aboriginal populations ($F = 13.41$; $p < 0.001$).

Not surprisingly, based on the literature, weight was found to be significantly related to diabetic status (aboriginal: $F = 7.70$; $p < 0.001$, non-aboriginal: $F = 6.34$; $p < 0.001$). As seen in Figure 6, the prevalence rate of diabetes generally increases with increasing weight.

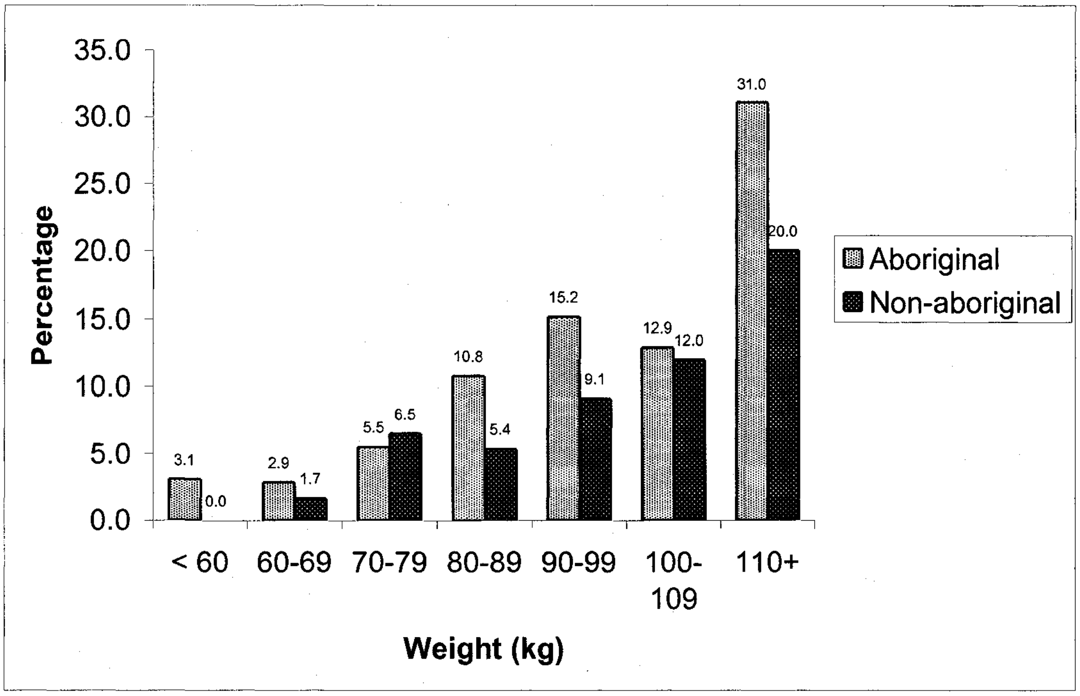

Figure 6. Prevalence rate of type 2 diabetes among aboriginal and non-aboriginal adults based on weight (kg).

With the exception of the 70 – 79 kg weight category, the aboriginal population had a higher prevalence rate of type 2 diabetes based on weight, with the difference being extremely apparent in the greater than 110 kg weight category (31.0% vs. 20.0%).

Body mass index is another measure used to evaluate a person's weight. This measure, however, takes a person's height into account and is often considered a more accurate evaluator of obesity. The calculation for body mass index (BMI) is:

$$BMI = \frac{Weight(kg)}{Height^2(m^2)}$$

Figure 7 illustrates the distribution of prevalence rates of type 2 diabetes in both the aboriginal and non-aboriginal populations based on body mass index.

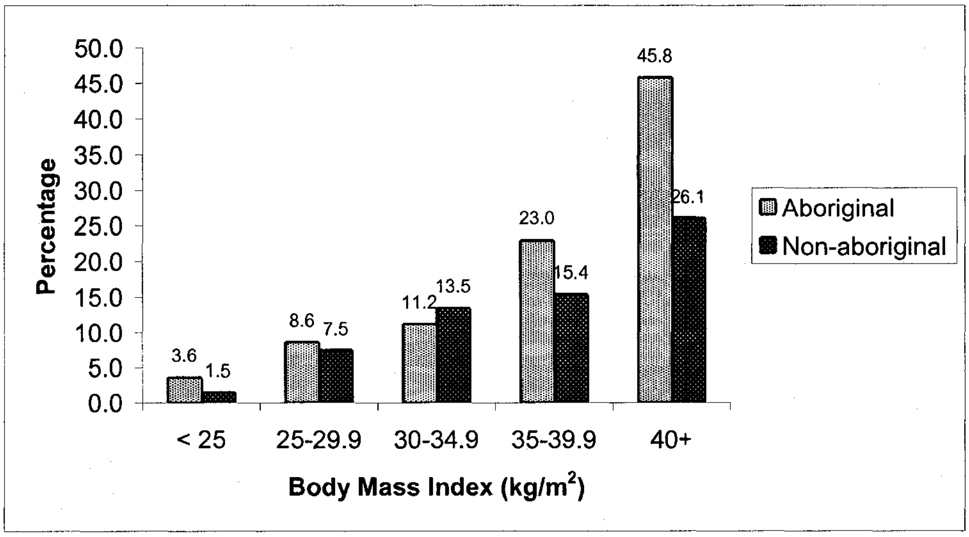

Figure 7. Prevalence rates of type 2 diabetes among aboriginal and non-aboriginal adults based on body mass index (kg/m^2).

In both the aboriginal and non-aboriginal populations, the prevalence of diabetes increases with increasing body mass index. The rate of increase seen is more substantial in the aboriginal population with the prevalence rate approximately doubling with each increase in body mass index category. The increase seen in the non-aboriginal population is more gradual. Despite these slightly different trends, body mass index is significantly related to diabetic status for both populations (aboriginal: $F = 15.3$; $p < 0.001$, non-aboriginal: $F = 8.02$; $p < 0.001$).

Logistic regression was used to provide a more detailed analysis of the increased risk of developing diabetes associated with age, weight, body mass index, gender, and aboriginal status. While the previous analyses elude to a significant relationship between the factors of age, weight, body mass index, and aboriginal status and diabetic status, logistic regression examines the contribution each factor makes to the overall risk of developing diabetes. Table 7 outlines the odds ratios and associated p values for gender, age, weight, body mass index, and aboriginal status. The results of both the univariate and multivariate analyses are included. For the multivariate model, both weight and body mass index could not be included in the same model due to the fact that these factors are highly correlated. Therefore, a choice had to be made with regards to which factor to include. Weight was chosen for the multivariate model because there was less data missing for this factor in the dataset, therefore the model using weight was a more accurate reflection of the study population.

Table 7. Odds Ratios (OR), p values and 95% Confidence Intervals (CI) for Diabetes from Univariate and Multivariate Logistic Regression Models

	Univariate Analysis[a]			Multivariate Analysis[b]		
Risk Factor	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Gender						
Male	Reference	--	--	Reference	--	--
Female	0.9	0.6 – 1.2	0.458	1.3	0.9 – 2.0	0.188
Age (years)						
18 – 34.9	Reference	--	--	Reference	--	--
35 – 44.9	9.8	2.2 – 43.7	0.003	10.8	2.4 – 48.7	0.002
45 – 54.9	21.4	5.1 – 90.7	0.000	24.0	5.6 – 103.2	0.000
55 – 64.9.9	62.2	14.9 – 259.6	0.000	78.0	18.2 – 333.4	0.000
≥ 65	68.6	16.5 – 286.0	0.000	107.4	25.0 – 460.9	0.000
Weight (kg)						
< 60	Reference	--	--	Reference	--	--
60 – 69	4.3	1.1 – 17.3	0.040	2.0	0.4 – 10.3	0.413
70 – 79	14.1	4.2 – 47.7	0.000	4.9	1.1 – 22.1	0.037
80 – 89	18.7	5.6 – 62.4	0.000	6.6	1.5 – 29.3	0.014
90 – 99	30.5	9.1 – 101.8	0.000	9.3	2.1 – 41.9	0.004
100 – 109	32.4	9.3 – 112.1	0.000	11.3	2.4 – 52.9	0.002
≥ 110	78.3	23.4 – 262.6	0.000	31.4	6.8 – 144.8	0.000
Body Mass Index (kg/m^2)						
< 25	Reference	--	--	Reference	--	--
25 – 29.9	7.0	3.1 – 16.2	0.000	N/A	--	--
30 – 34.9	12.1	5.2 – 28.0	0.000	N/A	--	--
35 – 39.9	21.2	9.0 – 49.7	0.000	N/A	--	--
≥ 40	56.1	23.2 – 135.4	0.000	N/A	--	--
Aboriginal Status						
Non-aboriginal	Reference	--	--	Reference	--	--
Aboriginal	1.4	1.0 – 2.0	0.053	3.0	2.0 – 4.6	0.000

[a] 5 univariate models with one risk factor in each logistic regression model.

[b] 1 multivariate model with 4 risk factors (gender, age, weight and aboriginal status) in the logistic regression model.

For the purposes of the logistic regression, the age groups of 18 – 24.9 years and 25 – 34.9 years had to be collapsed into one age group (18 – 34.9 years) due to the lack of cases of diabetes in the 18 – 24.9 years group. The lack of cases in this group makes it invalid as a reference group, and therefore makes the calculation of odds ratios impossible. The addition of the 25 – 34.9 years age group, which has two cases of diabetes, makes the combined group a valid reference group. For weight, the less than 60 kg group was chosen as the reference group because it is reasonable to assume that an adult weighing less than 60 kg should not be overweight and therefore, should be at a low risk of developing diabetes based on weight. A similar rationale was used in choosing the less than 25 kg/m^2 group as a reference for body mass index. According to the World Health Organization, a body mass index of less than 25 kg/m^2 is considered to be normal, while a body mass index of 30 kg/m^2 or greater is considered to be obese (Puska et al., 2003).

The results of the univariate model indicate that age, weight, and body mass index are all significant risk factors for developing diabetes. An increase in the value of any of these factors corresponds with an increase in the respective odd ratios. For example, the odds ratio for ages 35 through 44.9 years is 9.8, while the odds ratio for ages 55 through 64.9 is 62.2, an increase of more than 6 fold. Similar to the results found in the chi-squared analysis, gender was not found to be a significant risk factor for the development of diabetes. Aboriginal status, in the univariate model, was right on the cusp of being significant ($p = 0.053$) based on the set significance level of $p \leq 0.05$.

When comparing the univariate model to the multivariate model, the odds ratios are greater in the multivariate model than the univariate model for all of the risk factors with the exception of weight. Not only do the odds ratios decrease for weight in the multivariate model, but the 60 – 69 kg weight category is also not significant. In the univariate model, all of the weight categories are significant. In the multivariate model, aboriginal status becomes significant ($p = 0.000$) with the odds ratio doubling from the univariate model, from 1.4 to 3.0. Therefore, it can be interpreted that after controlling for all other factors, those with aboriginal ancestry are three times more likely to develop diabetes.

Chapter Five

Discussion

The findings of this study support what was previously reported in the literature regarding the prevalence of diabetes among aboriginal groups as compared to the general population. In the Bella Coola Valley study population, the crude prevalence of diabetes in the aboriginal population is more than one and half times that of the non-aboriginal population (9.7% vs. 5.7%). However, when the differences in the age distribution of the aboriginal and non-aboriginal populations are considered, and the prevalence rates are adjusted, the prevalence of diabetes in the aboriginal population is more than two and half times that of the non-aboriginal population (12.5% vs. 4.8%). This indicates that diabetes is of substantial concern to the aboriginal people of the Bella Coola Valley. The age-adjusted prevalence rate of diabetes for the non-aboriginal population is the same as what has been reported for the general population of Canada (Health Canada, 2002).

The age-adjusted prevalence rate of diabetes among the aboriginal people in Bella Coola is substantially higher than what has been previously reported for First Nations groups in British Columbia. Young, Szathmary, Evers and Wheatley (1990) did a survey of the prevalence of diabetes in First Nations groups across Canada and reported that the age-adjusted prevalence rate of diabetes among the First Nations population of British Columbia was 1.6%. While this survey is out-of-date now, another study of the prevalence of diabetes in British Columbia conducted in the late 1990's indicated that the crude prevalence rate of diabetes in First Nations people of all ages was 2.6%, still considerably lower than the crude prevalence rate found for the Bella Coola Valley aboriginal population. It is important to note, when comparing prevalence rates from different studies, the type of prevalence reported, crude or age-adjusted, and the age groups included. For example, a prevalence rate that includes only the adult population will usually be higher than a prevalence rate that includes all ages, because cases of type 2 diabetes are more likely to be found in adults than children.

In the review of the literature conducted prior to this study, three major trends in the prevalence rates of diabetes among aboriginal people were identified. The first trend identified was that the prevalence of diabetes increases with age. This trend was also seen in the Bella Coola Valley study population, for both the aboriginal and non-aboriginal populations (Figure 4 and 5). While both populations experienced an increase in prevalence rate with an increase in age, the amount of increase was much higher for the aboriginal population, from 0% in the 18 – 24.9 years category to 34.5% in the 65 years and greater category. A similar trend was found in a study comparing Indians to Caucasians in southwestern Ontario. In this study the prevalence of diabetes in the Indian population increased from 1.0% in the 15 – 24 years category to 43.8% in the 75 years and greater category, while the prevalence in the Caucasian population only increased from 0.5% to 13.2% in the same age groups (Evers et al., 1987).

In addition to the prevalence of diabetes increasing with age, another age related trend is seen specifically within the aboriginal populations. Aboriginal populations are experiencing a younger age of onset of diabetes as compared to the non-aboriginal populations. In the Bella Coola Valley study population, there were no cases of diabetes identified in the non-aboriginal population prior to the age of 40 years. However, in the aboriginal population a number of cases were identified in the 25 – 34.9 years age category. A younger age of onset has been observed in other studies of diabetes and aboriginal populations (Evers et al., 1987; Harris et al., 2003; Young, Reading, Elias, & O'Neil, 2000). The results of this study are particularly concerning with regards to the younger age of onset observed among aboriginal women. When the prevalence rate of diabetes is isolated to those aboriginals aged 25 – 39.9 years, there is a substantial difference between the sexes. While the prevalence rate for aboriginal men in this category was 0.8%, the prevalence rate of diabetes in aboriginal women for the same age group is 4.8%. The rate among aboriginal women in this age group is of concern because these are the primary childbearing years for a woman, and there is increasing evidence of a link between maternal diabetes and the subsequent development of diabetes in her offspring.

A study of the Pima Indians in Arizona found that 10 – 15% of pregnancies were complicated by diabetes (Dabelea et al., 2000). Infant macrosomia is often the result of diabetic pregnancies and can lead to such complications as the need for a caesarian section, birth trauma and injury, and infant morbidity (Rodrigues, Robinson, Kramer, & Gray-Donald, 2000). Some of the consequences to the children of maternal diabetics include increased risk of obesity and the development of type 2 diabetes. In the study of the Pima Indians it was found that approximately one-third of the cases of type 2 diabetes in children may have been the result of exposure to a diabetic intrauterine environment (Odds Ratio = 10.4). The link between maternal diabetes and the subsequent development of diabetes in offspring creates a vicious cycle in which diabetes can be perpetuated through the generations. A woman with diabetes is at risk for a complicated pregnancy and delivery. The infant, once born, is at an increased risk of being obese and developing type 2 diabetes. If that infant is a girl, she has the risk of developing type 2 diabetes before or during her childbearing years and, therefore, starting the whole cycle over again (Dabelea et al., 2000).

The second trend observed in the previous studies conducted on the prevalence of diabetes among aboriginal people is that the prevalence of diabetes is generally higher among women than men. This is a trend that has been well documented in the literature (Brassard et al., 1993; Burrows & Geiss, 2000; Delisle & Ekoe, 1993; Harris et al., 2003; Young, Szathmary et al., 1990), yet was not observed exactly in this study. For ages 25 – 44.9 years women did have a higher prevalence of diabetes, however from age 45 years and older, aboriginal men had the higher prevalence rates. Despite these trends the relationship between gender and diabetic status was not found to be significant in this study.

The final trend seen in the literature was that the prevalence of diabetes was related to the geographic location of the population. Of particular relevance to this study is the relationship between the remoteness of the location and the prevalence of diabetes. Other studies have found that the prevalence of diabetes is highest in urban communities and lowest in remote communities (Brassard et al., 1993; Young, Szathmary et al., 1990). While this study did not set out to specifically compare two geographic locations, it does stand to reason, given the isolated nature of the Bella Coola Valley, that the prevalence of diabetes should have been low. Compared to the remote communities studied in northern Quebec, the crude prevalence of diabetes in the First Nations people of the Bella Coola Valley is more than two and half times that of the James Bay Cree (9.7% vs. 3.4%) (Brassard et al., 1993). This indicates that type 2 diabetes is a significant factor for the aboriginal people of the Bella Coola Valley, and that the isolation of where they live may not have the same protective effect that is seen in other isolated aboriginal groups.

The prevalence of diabetes among the non-aboriginal populations has not been as extensively studied. Rather surveys of the general population are used to determine the prevalence of diabetes and other diseases and/or conditions. For example, the National Population Health Survey in 1998/99 determined that the prevalence of diabetes in the general population of Canada was 4.8% (Health Canada, 2002). While this is exact same age-adjusted prevalence rate that was found in the non-aboriginal population of the Bella Coola Valley, the crude prevalence rate in the non-aboriginal population was slightly higher (5.7%). Since the age-adjusted prevalence rates were adjusted to compensate for the age distribution differences between the aboriginal and non-aboriginal populations of the Bella Coola Valley, the crude prevalence rate is probably the better rate to use to compare the non-aboriginal population to other general populations. The National Population Health Survey in 1998/99 also found that men had a slightly higher prevalence of diabetes than women (5.0% vs. 4.6%) (Health Canada, 2002). This trend was also mirrored in the Bella Coola Valley non-aboriginal population with men having a diabetes prevalence rate of 6.2% while females had a rate of 5.1%. Another study of Canadian adults, age 40 years and older, found that men were 1.6 times more likely to have diabetes than women (Choi & Shi, 2001).

Several potential risk factors for diabetes were recorded for the Bella Coola Valley study population, including age, gender, weight, body mass index and aboriginal status. While this is not an exhaustive list of potential risk factors for diabetes, is does include many of the major risk factors identified in the literature, and are ones that can be easily abstracted from medical charts. Since the Bella Coola Valley study population included both aboriginal people and non-aboriginal people, it was possible to compare the two groups in terms of their prevalence of diabetes. In addition to this comparison, it was also possible to determine if there was a significant relationship between aboriginal ancestry and diabetic status, something that has not been done explicitly in the literature. Two Canadian studies were found that compared aboriginal people to non-aboriginal people with regard to the prevalence of diabetes (Evers et al., 1987; Pioro et al., 1996). While both of these studies compared the prevalence rates of diabetes, and other demographic and/or risk factor variables, neither study specifically examined the relationship between aboriginal ancestry and diabetic status looking for statistical significance. In the Bella Coola Valley study, both chi-squared analysis and logistic regression were used to investigate the relationship between aboriginal ancestry and diabetic status. It was determined through the chi-squared analysis that there is indeed a significant relationship between aboriginal ancestry and diabetic status ($\chi^2 = 10.183$; $p = 0.001$). Two different logistic regression models were used to explore the contribution of aboriginal status to the risk of developing diabetes. The first model was a univariate model that just looked at aboriginal status and diabetic status, without controlling for any other factors. The results of this analysis indicated that aboriginals were 1.4 times more likely to develop diabetes, though this relationship was not quite significant ($p = 0.053$) based on our set significance level of $p \leq 0.05$. The second model, a multivariate model, controlled for age, gender, and weight when examining the relationship between aboriginal status and diabetic status. The resulting odds ratio indicated that, after controlling for these other confounding factors, aboriginals are three times more likely to develop diabetes than non-aboriginals. This implies that, in addition to aboriginals just having a higher prevalence of diabetes, aboriginal ancestry is a significant risk factor for diabetes above and beyond age, gender and weight.

A well known fact about type 2 diabetes is that the prevalence of the disease increases with age. This trend was seen in the Bella Coola Valley study for both the aboriginal and non-aboriginal populations. Therefore, it was not surprising to discover that age is a significant risk factor for the development of diabetes. This determination was made through both the ANOVA and logistic regression analyses. Using the 18 –34.9 years category as a reference, the univariate logistic regression indicated that the risk of developing diabetes increases substantially with age. The increased risk is even more substantial when gender, weight and aboriginal status have been controlled for, as they were in the multivariate model. For example, the odds ratio for the 35 – 44.9 years age group increases from 9.8 to 10.8 when moving from the univariate to multivariate model. There is an even more drastic increase when looking at the 65 years and older age group, with the odds ratio going from 68.6 to 107.4. Choi and Shi (2001) found that the odds of developing diabetes increased by 9% per year of increase in age and Fletcher et al. (2002) noted that the fact that type 2 diabetes was previously referred to as adult-onset diabetes, which emphasizes the relationship between age and the risk of developing diabetes. This strong relationship between age and the risk for developing diabetes has been widely established and accepted within the literature and medical community, and has been further supported by this study (Jorgensen et al., 2002; Levin, Mayer-Davis, Ainsworth, Addy, & Wheeler, 2001; Young, Moffatt, & Ling, 1988).

Another commonly examined risk factor in association with diabetes is obesity. There are a variety of measurements used to evaluate obesity, including weight, body mass index, waist-to-hip ratios, and percentage of body fat. The most commonly reported measure of obesity is the body mass index (Jorgensen et al., 2002; Motala, Pirie, Gouws, Amod, & Omar, 2003; Young & Harris, 1994). While not a perfect measure, body mass index more accurately reflects the presence or absence of obesity because it measures weight in relation to height. Weight alone can be a very subjective measure because its health impact will vary depending on how that weight is distributed. For example, a person who weights 70 kg and is 1.5 m tall is far more overweight (BMI = 31 kg/m^2) than someone who weighs the same but is 1.8 m tall (BMI = 21 kg/m^2). In fact, according to the World Health Organization's definition of obesity, the person who weights 70 kg and is 1.5 m tall would be considered obese (BMI > 30 kg/m^2) while the person who weighs 70 kg and is 1.8 m tall would be considered as having a normal weight (BMI = 18.5 – 25 kg/m^2) (Puska et al., 2003). In the Bella Coola Valley study population this difference is illustrated by the fact that the mean weight of the non-aboriginal population is higher than the aboriginal population (70.87 ± 26.31 kg vs. 65.77 ± 30.45 kg), yet the non-aboriginal population has a lower mean body mass index (25.92 ± 6.33 kg/m^2 vs. 27.25 ± 8.02 kg/m^2).

Since both weight and body mass index values were available for analysis in this study, the relationships between both of these factors and diabetic status were explored. There was a general trend observed in both the aboriginal and non-aboriginal populations: as the weight increased so did the prevalence of diabetes. ANOVA analysis of the weight factor in relation to diabetic status revealed that, overall, weight was significantly related to diabetic status in both the aboriginal and non-aboriginal populations. The univariate logistic regression model indicated that all of the weight categories were significantly related to an increased risk of diabetes (Table 7). However, the multivariate logistic regression model indicated that having a weight of between 60 kg and 69 kg does not significantly increase one's risk of developing diabetes ($p = 0.413$). While there is a significant risk associated with weights of 70 kg and greater, these risks are lower in the multivariate model than the univariate model suggesting that after controlling for the potentially confounding effects of gender, age, and aboriginal status, weight makes less of a contribution to the overall risk of developing diabetes.

As previously mentioned, body mass index is the measure of obesity most commonly reported in the literature. Therefore, it is on this basis that we are more easily able to compare the results of this study with other studies looking at the risk factors associated with diabetes. According to a report by Health Canada (2002), approximately 38.0% of women and 59.7% of men, aged 20 to 59 years, reported being overweight in Canada in 1998/99. Of these cohorts of overweight individuals, 76.2% of the women and 72.9% of the men self-reported having diabetes. Choi and Shi (2001), in their study of the risk factors associated with diabetes, also found that the prevalence of diabetes increased with body mass index and that the odds ratios for body mass index, decreased from the univariate model to the multivariate. This is a trend that was seen in the Bella Coola Valley study in relation to weight, again supporting the notion that while obesity is an important contributor to the overall risk of developing diabetes, its contribution is somewhat diminished when other confounders are controlled for. Harris et al. (2003), in their study of the Ojibwa-Cree in northwest Ontario, found that body mass index was significantly associated with diabetes in both men and women in the 18-49 years age group, yet not in the greater than or equal to 50 years age group. They also reported that generally for a 5 kg/m^2 increase in body mass index the odds ratio was 2.39 (95% CI, 1.32 – 4.35). This is lower than the odds ratios determined in the study of the Bella Coola Valley population for body mass index. In this study, using a body mass index of less than 25 kg/m^2 as the reference, the odds ratios ranged from 7.0 (95% CI, 3.1 – 16.2) in the 25 – 29.9 kg/m^2 category to 56.1 (95% CI, 23.2 – 135.4) in the greater than or equal to 40 kg/m^2 category. Another study of the Ojibwa-Cree found that the odds ratio for a body mass index greater than or equal to 26 kg/m^2, when compared to a body mass index of less than 26 kg/m^2, was 4.51 (95% CI, 1.46 – 6.74) (Young, Sevenhuysen, Ling, &

Moffatt, 1990). These results are more similar to the results seen in the Bella Coola Valley study than the previously mentioned study by Harris et al., yet is still not as high as the odds ratios found in the Bella Coola Valley.

Type 2 diabetes is a chronic condition that affects over a million adults in Canada (Health Canada, 2002). Given the chronic nature of diabetes and the high incidence of subsequent complications and comorbidities seen in people with diabetes, this disease is associated with tremendous cost to both individuals and society as a whole. Many aboriginal groups across Canada are experiencing higher prevalence rates and greater severity of disease, while for others, type 2 diabetes is less frequent (Young, Szathmary et al., 1990). The variation seen in the prevalence rates of diabetes across different aboriginal groups indicates the need to study diabetes within the context of individual aboriginal groups. As shown by the discrepancy between what has been reported as the overall prevalence rate of diabetes in British Columbian aboriginal groups versus what was found in this study regarding the prevalence in the Bella Coola Valley, broad surveys of populations are not an accurate depiction of the problem of diabetes for individual aboriginal groups. The reported prevalence rates of diabetes in British Columbia for aboriginal people are very low by comparison to other aboriginal groups across Canada, and even lower than the prevalence rate reported for the general population of Canada (Johnson et al., 2002; Martin & Yidegiligne, 1998; Young, Szathmary et al., 1990). Based on this information, one could draw the conclusion that diabetes is not a significant issue for the aboriginal people of British Columbia, and therefore, is not a priority to be addressed at the community level or within the health care system. However, the study of the Bella Coola Valley shows that diabetes is indeed a significant health problem facing this population, especially for the aboriginal people, and that it must be addressed promptly.

Chapter Six

Implications of this Study

The results of this study indicate that diabetes is a significant health problem that needs to be addressed within the Bella Coola Valley community. The advantage in dealing with type 2 diabetes is that many of the risk factors associated with the disease are modifiable. While a person's age or aboriginal status cannot be changed, a person's weight and body mass index can be. For this reason most prevention strategies for type 2 diabetes centre around lifestyle modifications involving diet and exercise. In addition to focusing on individual behaviour changes, it is important that any prevention strategy also addresses the environment in which these people live and work, to make it supportive of healthy lifestyle choices. When working with aboriginal people, it is equally important to ensure that any intervention strategy is culturally sensitive to the traditions and beliefs of the community. One way to ensure that this occurs is to include representatives from the aboriginal group throughout the planning and implementation stages, thereby empowering them to be active participants in the intervention strategy.

This approach has been proven successful, within the context of diabetes, in such projects as the Kahnawake Schools Diabetes Prevention Project and the Sioux Lookout Diabetes Program. The Kahnawake Schools Diabetes Prevention Project is working to improve the healthy eating habits and increase the physical activity of the residents of Kahnawake, Quebec. There are two components to this project: the school component that targets elementary school children, and the community component that aims to foster community involvement and support. The school component, which consists of a "culturally relevant Health Education Program", has been the catalyst for other school-wide initiatives including a Nutrition Policy which ensures children are exposed only to nutritious foods while in school (Macaulay et al., 1998). The community has been actively involved in this project through the development of the Community Advisory Board, which has been a driving force in the planning, development and implementation of the overall program. It is thought by the authors that the strong community involvement and holistic approach are some of the major key components to the program's success. The Sioux Lookout Diabetes Program addresses both diabetes prevention and management through a variety of approaches including diabetes education, foot care services, and nutrition advice that includes a grocery store tour and budget food guide. Innovative programs such as a summer camp for youth with type 2 diabetes have been used to address the specific needs of the population within the context of their own culture (Morrison & Dooley, 1996).

This study can be used in support for the need to develop community programs to address diabetes in the Bella Coola Valley. The community could learn from such programs as those previously mentioned and work to establish their own community-based diabetes program. The Nuxalk Band Council has already taken an active interest in the health of their people and has shown their willingness to work with health care providers and researchers to improve the health of their community.

Chapter Seven

Future Research

This study has added to the limited body of literature on the prevalence of diabetes among the aboriginal people of British Columbia. It has also illustrated the need for individual specific study of different aboriginal groups, given the stark variation in prevalence rates observed. For the purposes of community level planning of programs and health care resources, province-wide surveys do not provide an accurate picture of the problem of diabetes among aboriginal communities.

Further research is required to gain a more comprehensive understanding of diabetes in the Bella Coola Valley and the modifiable risk factors most pertinent to this population such as obesity and physical inactivity. Another risk factor that should be explored is the role of family history in the development of diabetes in this community. The high prevalence of diabetes among aboriginal women aged 25 to 39 years observed in this study indicates that the potential link between the development of diabetes and maternal diabetes needs to be explored further in the Bella Coola Valley.

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Appendix I

Ethics Approval Certificate

Appendix II

Direct Age Adjustment of Prevalence Rates

	Aboriginal		Non-aboriginal	
Age	Population	# with diabetes	Population	# with diabetes
18 – 24.9	140	0	92	0
25 – 39.9	254	7 (2.75)*	247	0
40 – 44.9	72	5 (6.94)	113	3 (2.65)
45 – 64.9	195	38 (19.49)	394	30 (7.61)
65+	58	20 (34.48)	160	24 (15)
Total	719	70	1006	57

* Numbers in parentheses represent the prevalence rate per 100

Calculation of prevalence rate per 100:

$$\frac{7}{254} \times 100 = 2.75$$

Age	Total Population*	# cases expected Aboriginal	# cases expected Non-aboriginal
18 – 24.9	232	0	0
25 – 39.9	501	13.78	0
40 – 44.9	185	12.84	4.90
45 – 64.9	589	114.80	44.82
65+	218	75.17	32.7
Total	1725	216.59	82.42

* Total population calculated by adding the aboriginal and non-aboriginal populations for each age group

Calculation of expected # of cases:

$$\frac{2.75 \times 501}{100} = 13.78$$

Calculation of age-adjusted prevalence rates:

Aboriginal $$\frac{216.59}{1725} \times 100 = 12.55$$

Non-aboriginal $$\frac{82.42}{1725} \times 100 = 4.78$$