Status Report on the British Columbia Paediatric Diabetes Program

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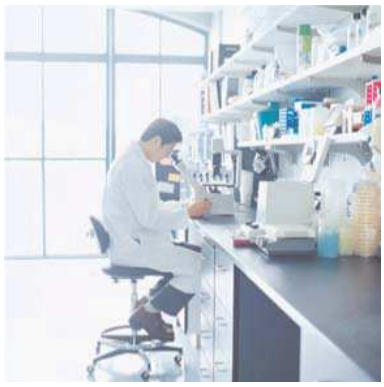

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Table of Contents

Status Report on the British Columbia Paediatric Diabetes Program

Executive Summary

The purpose of this report is to inform the activities of Child Health BC that are aimed at improving both the quality of and access to health care for children and youth with diabetes and other complex chronic disease. In particular, it is meant to serve as a directive step for the development of a provincial paediatric diabetes network in British Columbia.

Diabetes mellitus is a prevalent chronic disease, with an estimated 285 million cases in the world—a number that is poised to double in the next 20 years. Diabetes is serious no matter what the age of onset, but it is especially challenging when it afflicts the young. Worldwide, type 1 diabetes mellitus (T1DM) in children is increasing at an average annual rate of 2.8%. Although data are scarcer for type 2 diabetes mellitus (T2DM), it is also becoming more common in children, due in large part to rising childhood obesity rates. While rates of paediatric diabetes are increasing, care for this population is often suboptimal. A foundational step in improving diabetes care for paediatric patients is the collection and analysis of meaningful data that will inform policymakers, educate health practitioners, and guide health service delivery.

The larger context of this work is the vision of Child Health BC: *to build an integrated and accessible system of care for children in BC for the purpose of improving the health status and health outcomes for infants, children, and youth in British Columbia*. Child Health BC is a network of health authorities and health care providers established by BC Children's Hospital to fulfill this vision. In particular, the present project is drawing on the combined research efforts of clinicians and researchers at several agencies, including the:

- Population Health Surveillance and Epidemiology Branch at the BC Ministry of Healthy Living and Sport
- Provincial Health Services Authority
- BC Children's Hospital

Their research targets comprise the following questions:

1. What is paediatric diabetes in BC?
2. What is the quality of paediatric diabetes care in BC?
3. What are the consequences of paediatric diabetes?

In the absence of a comprehensive electronic clinical database, other approaches must be found to estimate the number of children with diabetes in BC and elsewhere. One common approach is to apply a validated case-finding definition to linked administrative data sets. There are a number of different case-finding definitions that can be applied to determine whether or not a patient has been diagnosed with diabetes, with the approach depending to some degree on the possibility of linking

two or more administrative data sets. For reasons outlined in the report, the case-finding definition developed by Canada's National Diabetes Surveillance System (now called the Canadian Chronic Disease Surveillance System) was adopted for the BC project. Further, an algorithm was developed and validated to categorize the estimated 4,019 paediatric diabetes cases in BC diagnosed over the 11-year period ending in fiscal 2006/07 as either T1DM (88.2%) or T2DM (11.8%).

The number of children diagnosed with T1DM was 301 incident cases in 1998/99 (an age-standardized incidence rate of 0.313 / 1,000 population) and 240 in 2006/07 (an age-standardized incidence rate of 0.255 / 1,000 population). The number of children diagnosed annually with T2DM was 30 in 1998/99 (an age-standardized incidence rate of 0.033 / 1,000 population) and 52 in 2006/07 (an age-standardized incidence rate of 0.055 / 1,000 population). The overall trend in the incidence rates of T1DM and T2DM between 1998/99 and 2006/07 is difficult to interpret because of the nature of the data and an unknown period of time that is required to achieve a steady state. For T1DM, if we assume a steady state is achieved in 2001/2002, the trend indicates minimal variation in the annual incidence of T1DM. For T2DM, previous studies and anecdotal reports indicate an increasing incidence in parallel to increasing rates of childhood obesity. The data in this report indicates a similar increasing trend in the incidence of childhood T2DM in BC. Another notable result in BC is the fact that, in females aged 15-19, the incidence rate of T2DM has now surpassed that of T1DM. Continued prospective surveillance will allow for a better understanding of these trends.

Steady or growing incidence combined with relatively low mortality generates an expanding pool of paediatric diabetes cases. This has implications for the ongoing burden of health care in BC in the near term. How much of the observed increase, however, is due to the required run-in period before a case-finding definition achieves a steady-state versus a true increase in age-standardized incidence is not currently known.

With better information on incidence and prevalence now established, this project will turn to the topic of the quality of care in relation to national and international clinical practise guidelines for paediatric diabetes patients in the province.

Introduction

Diabetes mellitus is a serious chronic condition affecting approximately 285 million people worldwide, and that figure is expected to rise by more than 50% in the next 20 years.[1] Incidence is also on the rise in children; in the under-15 age group the average annual increase in Type 1 diabetes mellitus (T1DM) world-wide is estimated at 2.8%.[2] The average annual increase is more rapid in younger children (4.0% in 0-4 year olds) compared to older children (2.1% in 10-14 year olds). Though less data is available for Type 2 diabetes mellitus (T2DM), it is also becoming increasingly common in children, due in large part to rising childhood obesity rates.[3,4,5] Despite recent increases in T2DM, T1DM still accounts for roughly 90% of diabetes in children, whereas the majority of diabetes in adults is T2DM. Diabetes in the young presents challenges beyond those involved with management of the disease in adults. Early appearance of diabetes presents an increased risk of complications with longer duration of the disease, and there are psychosocial issues associated with diabetes that have much greater impact in children and youth.

The level of diabetes care a child receives is generally suboptimal worldwide, varying widely depending on financial and health care resources available. The gap between recommended diabetes care and the care that people actually receive exists even in developed countries; this is not necessarily due to a lack of appropriate treatments for diabetes, but due to challenges in implementing them across the population.[6] A further barrier to optimal diabetes care is the lack of understanding of the full impact of diabetes on the child and his or her family, as well as the role of the community in the pursuit for comprehensive care.[7] A foundational step in improving diabetes care is the collection and analysis of meaningful data that will inform policymakers, educate health practitioners, and guide health service delivery.

BC Children's Hospital, in partnership with the Ministry of Healthy Living and Sport, is conducting a health services research study to describe the burden of paediatric diabetes in British Columbia. The overarching goal of this study is to answer the following questions:

4. What is paediatric diabetes in BC?
5. What is the quality of paediatric diabetes care in BC?
6. What are the consequences of paediatric diabetes?

The overall research portfolio involves linkage of clinical and non-clinical (i.e. educational, children in care) data sets, together with analysis of survey data (i.e. Canadian Community Health Survey, Aboriginal People's Survey), to describe not only incidence and prevalence of the disease but also patient demographics, healthcare utilization and associated costs, and psychosocial outcomes and school performance.

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[1] http://www.diabetesatlas.org/content/diabetes

[2] DIAMOND Project Group. Incidence and trends of childhood Type 1 diabetes worldwide 1990-1999. *Diabetic Medicine.* 2006; 23(8): 857-66.

[3] Pinhas-Hamiel O, Zeitler P. The global spread of type 2 diabetes mellitus in children and adolescents. *Journal of Pediatrics.* 2005; 146(5): 693-700.

[4] Schwartz MS, Chadha A. Type 2 diabetes mellitus in childhood: obesity and insulin resistance. *Journal of the American Osteopathic Association.* 2008; 108(9): 518-24.

[5] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

[6] Engelgau MM, Narayan KM, Saaddine JB et al. Addressing the burden of diabetes in the 21st century: better care and primary prevention. *Journal of the American Society of Nephrology.* 2003; 14(7 Suppl 2): S88-91.

[7] Aanstoot HJ, Anderson BJ, Daneman D et al. The global burden of youth diabetes: perspectives and potential. *Pediatric Diabetes.* 2007; 8 Suppl 8: 1-44.

This research study will inform the development of a paediatric diabetes network in BC and the results will be disseminated to key stakeholders across the province with the goal of informing health policy. It will also serve as a framework for the development of new and innovative health service delivery models for other complex chronic diseases of childhood.

Diabetes Mellitus

Type 1 Diabetes Mellitus

Type 1 diabetes mellitus (T1DM), formerly termed juvenile diabetes or insulin-dependent diabetes, results from autoimmune destruction of insulin-producing beta cells of the pancreas. This leads to a complete inability to produce insulin, a decrease in glucose uptake, and an increase in blood and urine glucose levels with the eventual development of diabetic ketoacidosis (DKA). In children with T1DM, DKA most commonly occurs at disease onset; the most devastating consequence of DKA is cerebral edema, which occurs in 5.1 episodes per 1000 cases of DKA in children <16 years of age.[8] The mortality rate from cerebral edema is 21–24%, and morbidity from serious neurological sequelae occurs in 15–35% of cases.[9,10,11] T1DM can be fatal unless treated with daily insulin replacement by injection.

The causes of T1DM are complex and not fully understood, but the disease is thought to develop "as a consequence of interaction(s) between genetic susceptibility and environmental factors."[12] T1DM cannot be prevented, nor is there a cure; it is a lifelong disease with potential to develop serious complications in young adulthood and risk of premature death. Medical complications may include early onset of cardiovascular disease, blindness, kidney failure, and neurological damage. Though poor glycemic control accelerates the development of complications, they may also occur in those who have received comprehensive diabetes care.[13] Recent evidence indicates that the duration of diabetes prior to onset of puberty and glycemic control during childhood and adolescence both play an important role in the development of complications.[14,15] Diabetes-related complications are not limited to the medical realm; there are considerable psychosocial issues associated with the disease, especially among children and adolescents. The burden of diabetes, in addition to normal developmental challenges, is often difficult for young people to manage, and can lead to anxiety and depression.[16] Persistent non-compliance is present in over 40% of teenagers with T1DM who are also at risk for serious psychopathology that extends into early adulthood.[17] Sub-threshold eating disorders are almost twice as common in adolescent females with T1DM compared to non-diabetic controls.[18] T1DM may also have an impact on school performance and

[8] Lawrence SE. Diagnosis and treatment of diabetic ketoacidosis in children and adolescents. *Paediatrics & Child Health.* 2005; 10(1): 21-4.
[9] Lawrence SE. Diagnosis and treatment of diabetic ketoacidosis in children and adolescents. *Paediatrics & Child Health.* 2005; 10(1): 21-4.
[10] Edge JA, Hawkins MM, Winter DL et al. The risk and outcome of cerebral oedema developing during diabetic ketoacidosis. *Archives of Disease in Childhood.* 2001; 85(1): 16-22.
[11] Glaser N. Cerebral edema in children with diabetic ketoacidosis. *Current Diabetes Reports.* 2001; 1(1): 41-6.
[12] Green A. Descriptive epidemiology of type 1 diabetes in youth: Incidence, mortality, prevalence, and secular trends. *Endocrine Research.* 2008; 33(1-2): 1-15.
[13] Svensson M, Eriksson JW, Dahlquist G. Early glycemic control, age at onset, and development of microvascular complications in childhood-onset type 1 diabetes: a population-based study in northern Sweden. *Diabetes Care.* 2004; 27(4): 955-62.
[14] Daneman D. Early diabetes-related complications in adolescents: risk factors and screening. *Hormone Research.* 2005; 63(2): 75-85.
[15] Donaghue KC, Fairchild JM, Craig ME et al. Do all prepubertal years of diabetes duration contribute equally to diabetes complications? *Diabetes Care.* 2003; 26(4): 1224-9.
[16] Schiffrin A. Psychosocial issues in pediatric diabetes. *Current Diabetes Reports.* 2001; 1(1): 33-40.
[17] Kovacs M, Goldston D, Obrosky DS et al. Prevalence and predictors of pervasive noncompliance with medical treatment among youths with insulin-dependent diabetes mellitus. *Journal of the American Academy of Child and Adolescent Psychiatry.* 1992; 31(6): 1112-9.
[18] Jones JM, Lawson ML, Daneman D et al. Eating disorders in adolescent females with and without type 1 diabetes: cross sectional study. *British Medical Journal.* 2000; 320(7249): 1563-6.

family functioning. These psychosocial complications of diabetes frequently result in inadequate self-management of the disease.

T1DM accounts for approximately 10% of all cases of diabetes in the general population; however, it is the predominant type of newly diagnosed diabetes in children, accounting for roughly 90% of all cases. An estimated 75% of all newly-diagnosed T1DM cases occur in individuals under the age of 18. There is an increasing trend in the incidence of childhood onset diabetes that appears to be a global phenomenon; the overall annual increase is estimated at 2-5%, with the greatest increase occurring in those under 4 years of age, as noted earlier.[19]

Type 2 Diabetes Mellitus

Type 2 diabetes mellitus (T2DM), formerly called adult onset diabetes or noninsulin-dependent diabetes mellitus, is caused by insulin resistance followed by a relative insulin deficiency, resulting in elevated blood glucose levels. This type of diabetes, unlike T1DM, tends to develop gradually; symptoms are often mild and could go unnoticed for years. However, as with T1DM, poor glycemic control can lead to serious complications. In children and youth, the single most important risk factor for T2DM is obesity; in a surveillance study of newly diagnosed T2DM in Canadian children, 95% of patients were obese.[20] Of the children diagnosed with T2DM (average age 13.5 years), 37% had at least one co-morbidity at diagnosis, including high blood pressure, high cholesterol, or fatty liver disease. Risk factors other than obesity include a family history of T2DM, belonging to a high risk ethnic group, evidence of insulin resistance, presence of impaired glucose tolerance, and use of atypical antipsychotic medications.[21] The onset of the disease can be delayed or even entirely prevented by diet, exercise, and/or weight loss; initial treatment of T2DM usually entails such lifestyle modifications. For individuals who cannot achieve glycemic control via these methods, therapy with metformin and/or insulin may be required.

Although T2DM historically affected only adults over 40 years of age, it is becoming increasingly common in children. Rising childhood obesity rates and increasingly sedentary lifestyles are considered to be major contributors to this rise in childhood T2DM. Some ethnic populations are at particularly high risk; in the surveillance study of T2DM in Canadian children, 44% of patients were Aboriginal, and 25% were Asian, African/Caribbean, or Hispanic.[22] The remaining 25% were Caucasian, an ethnic group that previously hasn't been labelled 'at-risk'. The true magnitude of T2DM in youth may be underestimated, due in part to a lack of comprehensive registries and population-based studies. Additionally, distinguishing between T1DM and T2DM in children and adolescents can be difficult, potentially resulting in misclassification of diabetes.[23] As discussed above, symptoms of T2DM may often go undetected for some time; consequently, there may be many undiagnosed cases of T2DM.

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[19] Aanstoot HJ, Anderson BJ, Daneman D et al. The global burden of youth diabetes: perspectives and potential. *Pediatric Diabetes.* 2007; 8 Suppl 8: 1-44.

[20] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

[21] Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2008 clinical practice guidelines for the prevention and management of diabetes in Canada. *Canadian Journal of Diabetes.* 2008; 32(Suppl 1): S1-S201.

[22] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

[23] Aanstoot HJ, Anderson BJ, Daneman D et al. The global burden of youth diabetes: perspectives and potential. *Pediatric Diabetes.* 2007; 8 Suppl 8: 1-44.

Population-based studies on the incidence of T2DM in children are limited and currently produce variable results, possibly due to different methods of determining the number of children with T2DM. In addition, non-T1DM diabetes in children includes several other types of diabetes in addition to T2DM (e.g. medication-induced and monogenic diabetes), creating further challenges in assessing true incidence of T2DM in children. Research in the U.K suggests an incidence rate for T2DM in children of 0.53/100,000/year compared to 8.10/100,000 person-years in the U.S.[24,25] A recent Canadian study estimated the minimum incidence to be 1.54/100,000/year.[26] The Canadian study also found significant variance in incidence rates by ethnic background and region of the country. The highest incidence rates were found in Aboriginal (23.2/100,000/year) children, followed by Asian (7.7), African/Caribbean (1.9) and Caucasian (0.54) children. Rates in Canadian provinces ranged from 0.4 to 12.5/100,000/year children.

[24] Haines L, Wan KC, Lynn R et al. Rising incidence of type 2 diabetes in children in the U.K. *Diabetes Care.* 2007; 30(5): 1097-101.

[25] Dabelea D, Bell RA, D'Agostino RB, Jr. et al. Incidence of diabetes in youth in the United States. *Journal of the American Medical Association.* 2007; 297(24): 2716-24.

[26] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

Current Research Project

The research described in this report represents the combined efforts of several BC agencies including:

- Clinicians and researchers at BC Children's Hospital
- Population Health Surveillance and Epidemiology Branch at the BC Ministry of Healthy Living and Sport.
- Provincial Health Services Authority

The new strategic direction of BC Children's Hospital through the activities of Child Health BC is: "*to build an integrated and accessible system of care for children in BC for the purpose of improving the health status and health outcomes for infants, children, and youth in British Columbia*."

The current research focuses on paediatric diabetes using BC's existing experience with the BC Diabetes Collaborative which only describes diabetes in adults. The research, using paediatric diabetes as a prototype, will explore and validate the use of linked health datasets to describe the epidemiological trends (i.e. incidence and prevalence), health care utilization, and quality of health care services in children and youth with complex chronic disease.

The research will directly inform the activities of Child Health BC in improving both the quality of and access to health care for children and youth with diabetes living in BC. It will also serve as a directive step for the development of a provincial paediatric diabetes network in BC, and subsequently other chronic disease networks specific to children and youth.

This report describes the methodology and results for the following objectives:

1. **Validate a paediatric diabetes case finding definition for use within linked administrative data sets.**
2. **Develop an algorithm to differentiate T1DM and T2DM in children using linked health data sets.**
3. **Explore epidemiological trends (incidence, prevalence) of T1DM and T2DM in children living in BC using existing provincial data sources.**

Work Completed to Date

A key objective of the current research is to use existing data sources for the surveillance of chronic disease in children and youth and to identify indicators of process and health outcomes. The key data sources used are briefly described in the following section.

Data Sources

Medical Services Plan (MSP)

The main source for information on physician services and expenditures in British Columbia is the Medical Services Plan. The MSP database files include fee-for-service (FFS) payments to BC physicians for services to BC and non-BC residents. Approximately 80% of BC physicians are self-employed professionals working on a fee-for-service (FFS) basis. In the FFS system, the MSP pays physicians an established fee for each service provided to each patient. Fees compensate physicians for their professional services and pay for overhead including staff salaries, medical equipment, supplies, rent, continuing education, insurance, business licenses, and other costs associated with running a business. Physicians billing FFS must submit claims to MSP in a computer-readable format within 90 days of the service date.

While the majority of BC physicians are paid through MSP, there is another group of physicians who are paid through salaried or sessional arrangements. Salaried physicians are typically on staff at hospitals, private corporations, government agencies or universities. For example, medical directors of health authorities and physicians employed by the BC Cancer Agency, Riverview Hospital, or Centre for Disease Control, and regional and provincial medical health officers, are salaried. Sessional payments are used primarily for physicians working in mental health and palliative care. The sessional payment is based on time, rather than service provided.

A higher proportion of general practitioner fees (~98%) as compared to specialist physician fees (~77%) tend to be paid through MSP.[27]

Acute Care – Discharge Abstract Database (DAD)

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

PharmaNet

PharmaNet is the province-wide network that links all BC pharmacies to a central set of data systems. Every prescription dispensed in BC (excluding those provided in a hospital) is entered into PharmaNet– approximately 47 million prescriptions annually. Among the data included are the drugs dispensed, reported drug allergies and clinical conditions, demographic information such as an individual's Personal Health Number, name, address and date of birth, drug information and drug interaction evaluations and claims information including eligibility, coverage and deductibles.

[27] Krueger H. *The Benefits of Investing in Appropriate Diabetes Care*. Germany: VDM Verlag; 2008.

Client Registry and Registration & Premium Billing

Registration and Premium Billing is the branch of MSP that is responsible for registering residents for coverage, maintaining client demographic information, and billing clients for premiums. The Client Registry is maintained by the Ministry of Health Services and is intended to keep track of persons and organizations served by, or providing service to the Ministry, as well as new Personal Health Numbers. As such, these sources are generally used for geographic and demographic information.

Validating a Case-Finding Definition

Overview

When using population-based health administrative datasets (such as those described under *Data Sources* above), there are a number of different approaches or case-finding definitions that can be applied to determine whether or not a patient has been diagnosed with diabetes. The approach depends to some degree on the possibility of linking two or more administrative data sets. Among the most common of these approaches to identifying persons <20 years of age with diabetes are the following:

1. At least four physician visits with the relevant diabetes code within a moving two-year (730-day) period, used in Ontario.[28]
2. At least two physician visits in a moving two-year (730 day) period or one hospital discharge, with the relevant diabetes code. This case-finding definition is used by the Public Health Agency of Canada's National Diabetes Surveillance System (NDSS).
3. A case-finding definition proposed in BC based on any of the following within a moving one-year (365 day) period:
   a. At least one hospital discharge with the relevant diabetes code
   b. At least two physicians visits with the relevant diabetes code
   c. At least two insulin prescriptions
   d. At least two oral antidiabetic agent (excluding metformin) prescriptions
   e. One insulin and one oral antidiabetic agent
   f. At least two metformin prescriptions and one physician visit with the relevant diabetes code

In each case, an attempt is made to exclude gestational diabetes.

The first (Ontario) approach requires access to population-based physician administrative data only (i.e. no linkage is required). The second (NDSS) approach requires access to and linkage of population-based hospital and physician administrative data sets. The third (BC) approach requires access to and linkage of a population-based pharmacy prescription data set in addition to hospital and physician data.

Validation of the Case-finding Definition

When the third approach was applied to BC data sources for the fiscal years between 1992/93 and 2007/08, a total of 6,753 cases of paediatric diabetes (less than 20 years of age) were identified. These cases were then compared to diagnosed cases in the BC Children's Hospital (BCCH) clinical database. Unfortunately, not all children with diabetes are seen at BCCH. Of the 2,611 who were

[28] Guttmann A, Nakhla M, Henderson M et al. Validation of a health administrative data algorithm for assessing the epidemiology of diabetes in Canadian children. *Pediatric Diabetes.* 2010; 11(2): 122-8.

included in the BCCH clinical database, 2,552 (97.7%) were also identified by the BC case-finding definition, 2,521 (96.6%) by the NDSS and 2,311 (88.5%) by the Ontario case-finding definitions (see Table 1).

Table 1. Comparison of Three Paediatric Diabetes Case-Finding Definitions

	Case-Finding Definition					
	BC		NDSS		Ontario	
	N	%	N	%	N	%
Met Case Definition (Diabetes)	2,552	97.7%	2,521	96.6%	2,311	88.5%
Did Not Meet Case Definition (No Diabetes)	59	2.3%	90	3.4%	300	11.5%
Total	**2,611**	**100.0%**	**2,611**	**100.0%**	**2,611**	**100.0%**

This suggests that the sensitivity of the BC case-finding definition in identifying true cases of paediatric diabetes is very high (97.7%) although the NDSS definition also fared well at 96.6%. What is not known, and will therefore require further research, is whether the case-finding definitions also identified a significant number of cases that do not actually have diabetes (false positives).

Ultimately, it was decided to utilize the NDSS case-finding definition for the current project. There are several reasons for this. The sensitivity of the NDSS definition is almost as high as the BC definition but does not require access to, and linkage with, a pharmaceutical data set. Few provinces in Canada have access to such linked data. Also, validation of the NDSS definition in the <20 year population in Ontario indicated a sensitivity of 100% and a specificity of 94.2%.[29] The NDSS is also used nationally and thus would allow for comparisons between provinces in the future.

Developing an Algorithm to Differentiate T1DM and T2DM

A significant limitation in using administrative data for diabetes surveillance is the inability to differentiate T1DM and T2DM. At present, it is assumed that all diabetes in persons <20 years of age is T1DM and in persons >20 years of age is T2DM. Therefore, our team has put in a considerable amount of effort in developing an algorithm designed to differentiate between T1DM and T2DM within administrative datasets. The approach took advantage of the unique prescription data set (PharmaNet) available in BC. It was assumed that an analysis of the type and timing of prescriptions would lead to a valid algorithm.

The prescriptions of interest are as follows:

- Insulin (therapeutic code = 682008)
- Metformin (therapeutic code = 68209202)
- Glucose monitoring test strips (therapeutic code = 989950031)
- Oral antidiabetic agents, excluding metformin (therapeutic codes = 682020,68209203,68209204 and 68209205)

[29] Guttmann A, Nakhla M, Henderson M et al. Validation of a health administrative data algorithm for assessing the epidemiology of diabetes in Canadian children. *Pediatric Diabetes.* 2010; 11(2): 122-8.

The timing of the prescription was coded into the following four discrete time periods:

i. Between 0 and 182 days (0-6 months) from the date the patient was identified as having diabetes (index date) based on the NDSS algorithm noted above.
ii. Between 183 and 365 days (6-12 months)
iii. Between 366 and 548 days (12-18 months)
iv. Between 549 and 730 days (18-24 months)

Developing the cohort of children and youth with diabetes included the following steps:

a. Apply the NDSS case-finding definition to all children in B.C. between 1996/97 and 2006/07 – 5,151 cases

b. Remove deaths (=14), those not living in the province for a minimum of 2 years (=182), those <1 years of age at time of diagnosis (=13)

c. 882 of the 5,151 cases had **no prescription data for any of the prescriptions of interest at any time during the study period**. Further analysis of this group determined that:

- **263 were not Aboriginal status and were less than 10 years of age**. Because T2DM is uncommon in this age group, it was assumed that these were most likely to be cases of T1DM. T1DM requires treatment with insulin. Since there is no evidence of insulin utilization in this group, it is likely that these 263 cases are false positives. Alternately, a proportion of these cases could have a genetic form of diabetes (monogenic diabetes) or cystic fibrosis-related diabetes that is often treated with diet and exercise. Thus, because the intention is to identify cases of T1DM and T2DM, removing any such cases from the cohort would have minimal impact on the results.

- **62 were Aboriginal status and 557 were not Aboriginal status and ≥10 years of age or older**. These cases may be: (i) false positives; (ii) a suspected but not true case of diabetes that was identified with a diagnostic code indicating diabetes by a physician; or (iii) T2DM treated with diet and lifestyle. Inclusion of these cases, if false positives, would result in an overestimation and exclusion of these cases, if true positives, would result in an underestimation of rates of T1DM and T2DM. Although these cases were excluded from the cohort, they were classified into an "at-risk" cohort that will continue to be observed within the administrative dataset. The decision to exclude these cases was based on the following:

    i. Further analysis compared the 557 cases that were not Aboriginal status and ≥10 years of age to the same group that had prescription data. The 'no prescription' group of 557 cases had significantly fewer diabetes-related physician visits (3.3 vs. 30.4 MSP claims) and were more likely to have a code for obesity (14% versus 8%). This suggests that these are either patients potentially at-risk for diabetes or were suspected of having diabetes, but the diagnosis was not confirmed at subsequent physician visits.

    ii. Clinical experience indicates that fewer than 10% of patients with T2DM treated with diet and exercise alone are able to achieve adequate glycemic control.[30]

    iii. A recent Canadian study on childhood T2DM indicated that roughly 10% of children and youth with T2DM in BC are treated with lifestyle modification alone.[31]

[30] Silverstein JH, Rosenbloom AL. Type 2 diabetes in children. *Current Diabetes Reports.* 2001; 1(1): 19-27.

Further analysis of the **4,060 cases with prescription data** was conducted to examine drug utilization patterns. Individual case files were aggregated into common 'anti-diabetic' prescription patterns for consecutive six-month periods for the first 24-months after the case was identified as having diabetes in the administrative data (index date). These common prescription patterns were then reviewed to assess their consistency with T1DM or T2DM, or both. Through an iterative process, 4 algorithms combining demographic rules and drug utilization patterns were developed for validation. Details of this analysis are outlined in Appendix A.

For convenience, the four algorithms are labelled "A", "B", "C", and "D", each reflecting specific demographic characteristics and prescription drug utilization patterns common in diabetes. The following three criteria were used to shape the algorithms; (1) Aboriginal status, (2) age, and (3) prescription drug utilization pattern (see Figure 1).

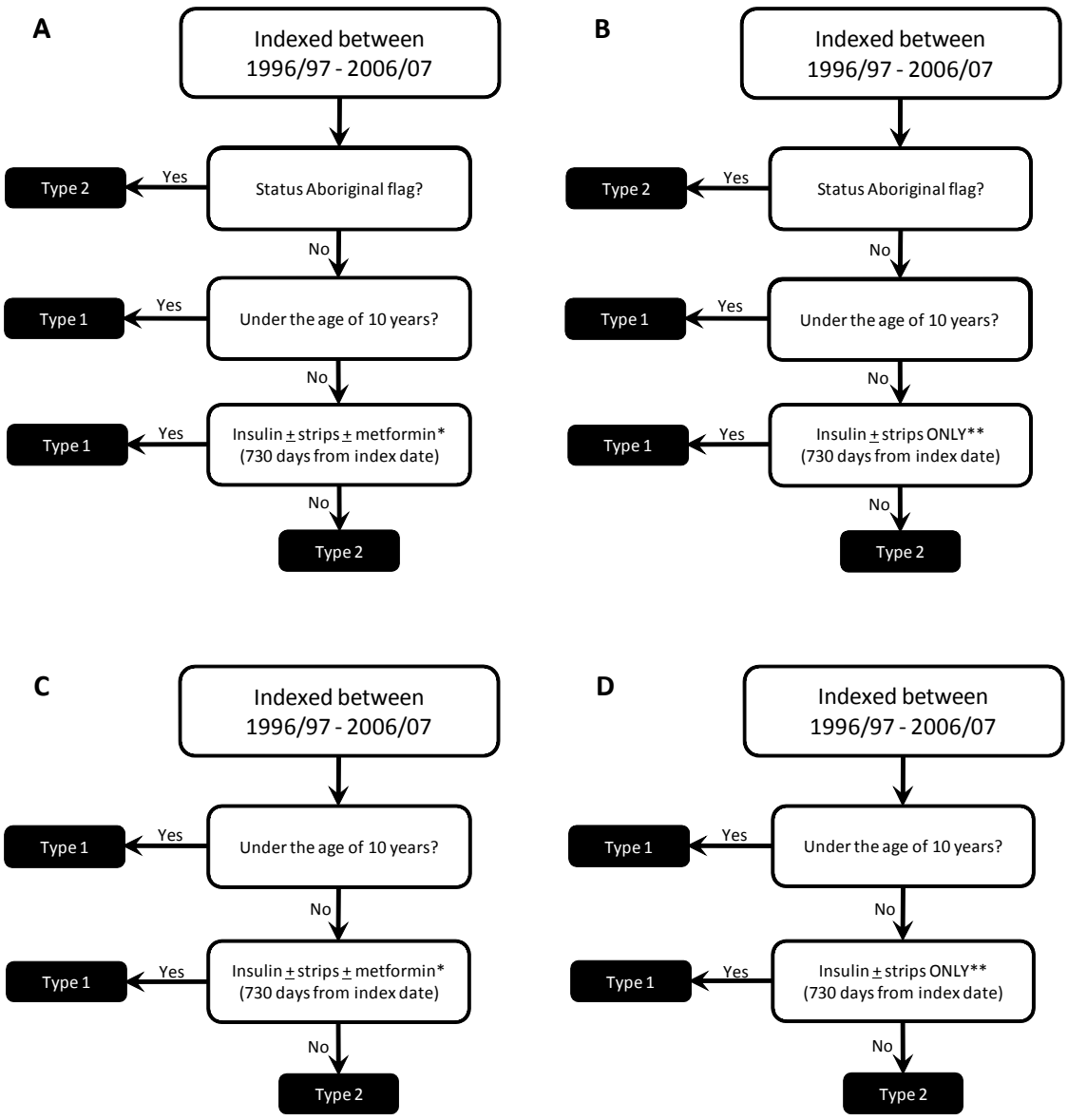
For algorithms A and B, individuals were identified as Status Aboriginals through the use of a group number in the Registration and Premium Billing database that flags individuals registered as "Status Indians" under the Canadian Indian Act. In algorithms A and B, all children who were Status Aboriginals were classified as T2DM and children who were not Status and less than 10 years on their index date were classified as T1DM.

In algorithms C and D, the Status Aboriginal rule was removed; however, children less than 10 years continued to be classified as T1DM.

The final rule was based on expected differences in drug utilization patterns between children with T1DM and T2DM. Clinical expertise indicated that metformin, although typically used in T2DM, is occasionally prescribed in pubertal children with T1DM who are obese and have insulin resistance. Therefore, classification of T1DM in algorithms A and C versus B and D differed. In the former algorithms, cases with insulin alone or in combination with glucose monitoring strips, or metformin prescribed 24 months following the index date were classified as T1DM. In the latter, any combinations of insulin with or without glucose monitoring strips only were classified as T1DM. Otherwise, subjects were categorized to have T2DM. Any other prescription drug utilization patterns, such as those with other oral antidiabetic agents in combination with any other prescriptions (including insulin) or those with drug utilization patterns that did not include insulin were categorized to have T2DM.

[31] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

Figure 1. Provisional Algorithms



*Insulin only; or, insulin + strips only; or, insulin + metformin only; or, insulin + strips + metformin.
**Insulin only; or, insulin + strips only.

Validation of the Algorithm

Each of the four algorithms were validated against a gold standard to determine their accuracy in identifying cases of T1DM and T2DM; validity was measured by determining the number of true positives, true negatives, false positives, and false negatives. The "gold standard" was the clinical database of children seen at the BC Children's Hospital (BCCH) Endocrinology and Diabetes Unit (EDU). A strength of the clinical database is that diabetes diagnosis and type were determined by a pediatric endocrinologist. A limitation however is that the diabetes clinic at BCCH does not see all children with diabetes in the province and therefore, may not be truly representative of the BC

population of children with diabetes. The sensitivity (Sn) and specificity (Sp) values were calculated for each provisional algorithm. Confidence intervals (CIs) at 95% were computed using the efficient score method, with correction, as described by Newcombe.[32] The aim was to determine which algorithms would achieve a balance of high sensitivity and high specificity in identifying diabetes type.

Results

There were a total of 1,323 pediatric diabetes cases seen at the EDU diabetes clinic between 1996/97 – 2006/07, suggesting that approximately 25% of children and adolescents with diabetes identified from the BC administrative data were seen at this tertiary care centre. Of these cases, 1,199 had diagnoses of T1DM, 101 were T2DM, and 23 were maturity-onset diabetes of the young (MODY).

Table 2 presents the validation results of the four algorithms' abilities to properly classify cases as T1DM. Algorithms that included the use of the 'Status-Aboriginal-as-type-2' rule (algorithms A and B) tended to generate more false negatives. Conversely, a drug utilization pattern for T1DM that included metformin (algorithms A and C) led to more false positives as compared to when the drug pattern usage was limited to insulin and glucose monitoring strips only (algorithms B and D). Generally, algorithms B and D performed well at classifying T1DM. Algorithm D was more sensitive than algorithm B at classifying T1DM (Sn=98.6% (95% CI: 97.7%-99.2%) and Sn=96.9% (95% CI: 95.7%-97.8%), respectively); however, it was less specific than algorithm B (Sp=78.2% (95% CI: 69.7%-85.2%) and Sp=79.0% (95% CI: 70.6%-85.9%), respectively).

Table 2. Validation of Algorithms to Identify Type 1 Diabetes (95% CI)

Algorithm	TP	FP	TN	FN	Sensitivity (%)	Specificity (%)
A	1,169	53	71	30	97.5 (96.4 - 98.3)	57.3 (48.1 - 66.2)
B	1,162	26	98	37	96.9 (95.7 - 97.8)	79.0 (70.6 - 85.9)
C	1,190	55	69	9	99.2 (98.5 - 99.7)	55.6 (46.5 - 64.6)
D	1,182	27	97	17	98.6 (97.7 - 99.2)	78.2 (69.7 - 85.2)

CI = Confidence Interval; TP = True Positive; FP = False Positive; TN = True Negative; FN = False Negative

When the algorithms were tested for their ability to correctly identify cases of T2DM, the algorithms were less accurate overall than they were for identifying T1DM (see Table 3). It was challenging to identify an optimal algorithm using this application as algorithms B and D (those that included metformin in the type 2 rule) produced similar results. While the algorithm that included the Status Aboriginal rule (B) was more sensitive in identifying type 2 diabetes than the algorithm that did not include this rule (D) (Sn=84.2% (95% CI: 75.2%-90.8%) versus Sn=83.2% (95% CI: 74.1%-90.0%), respectively), the opposite pattern pertained to specificity (Sp=95.9% (95% CI: 94.6%-96.9%) versus Sp=97.5% (95% CI: 96.5%-98.3%), respectively).

[32] Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of several methods. *Statistics in Medicine*, 1998;17:857-72.

Table 3. Validation of Algorithms to Identify Type 2 Diabetes (95% CI)

Algorithm	TP	FP	TN	FN	Sensitivity (%)	Specificity (%)
A	58	43	1,179	43	57.4 (47.2 - 67.3)	96.5 (95.2 - 97.4)
B	85	50	1,172	16	84.2 (75.2 - 90.8)	95.9 (94.6 - 96.9)
C	56	22	1,200	45	55.4 (45.2 - 65.4)	98.2 (97.2 - 98.9)
D	84	30	1,192	17	83.2 (74.1 - 90.0)	97.5 (96.5 - 98.3)

CI = Confidence Interval; TP = True Positive; FP = False Positive; TN = True Negative; FN = False Negative

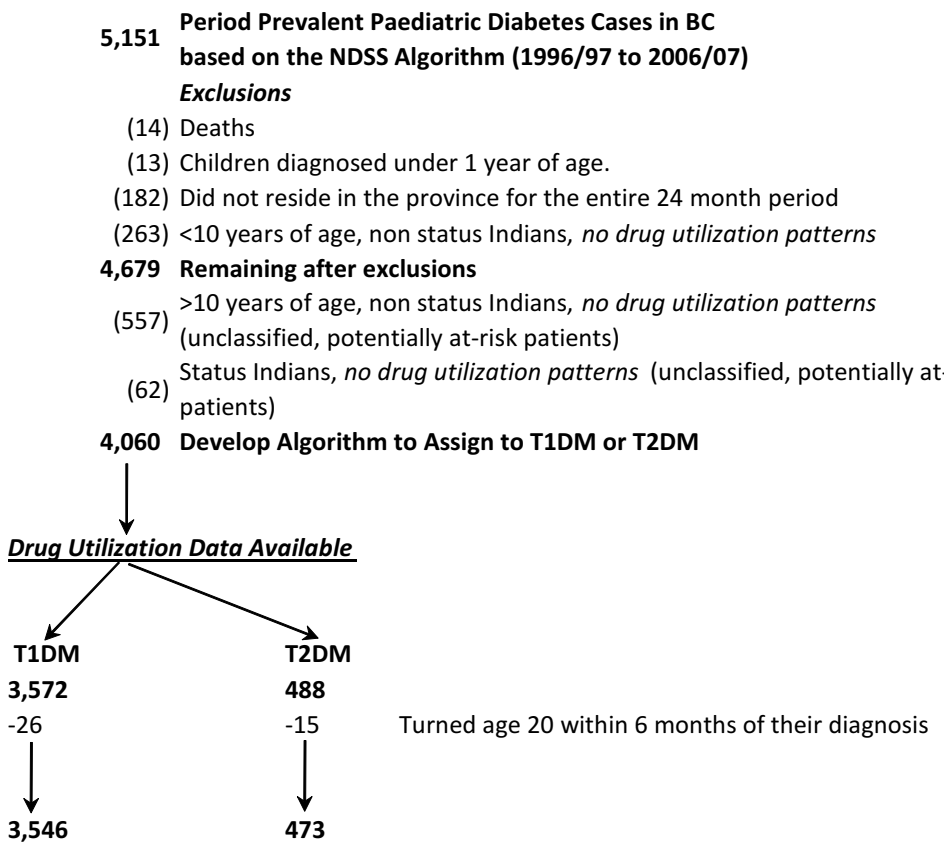
Based on a clinical cohort of diabetes cases in BC, the classification algorithms based on age and prescription drug utilization patterns were highly sensitive and specific in identifying diabetes type. Definitions based primarily on an age rule (i.e., type 1 if <10 yrs: C and D) were most sensitive in the identification of T1DM, whereas algorithms with restrictions on drug utilization (i.e., type 1 if insulin ± glucose monitoring strips only: B and D) were most sensitive for identifying T2DM.

When the algorithms were tested for classification of T1DM, the Status Aboriginal rule (i.e., T2DM if Status Aboriginal: algorithms A and B) tended to generate more false negatives. This observation indicates that there may have been a higher proportion of T1DM cases among Aboriginal children and adolescents in our population than originally postulated. Validation of the algorithms to identify T2DM suggested that the use of metformin was a key indicator for this type (B and D).

Algorithm D showed strong sensitivity and specificity for both T1DM and T2DM and also used the simplest definition of the four algorithms tested (i.e., required the least amount of information to classify diabetes type). The simplicity of this definition is appealing, as it improves the broader applicability of the algorithms. As noted earlier, there were **4,060 cases of diabetes in children <20 years of age with prescription data; Algorithm D was applied to this cohort in order to describe incidence and prevalence of T1DM and T2DM in children in BC (see below).**

The results, including a summary of the exclusions applied to derive the 4,060 cases, are shown in Figure 2. Of the 4,060 cases, 41 had their 20th birthday within the six month period following their diagnosis. These cases were excluded to ensure there was consistency in the calculation of rates, a situation that is particularly problematic in the calculation of age-specific rates. Because the population denominator for rates is selected at a specific point in time (i.e. October 1st) and age at diagnosis is determined relative to the individual date of birth, removing these cases ensured that the population denominator was stable across all rate calculations.

Figure 2: Period Prevalent* Paediatric Diabetes Cases in British Columbia



Note: ** Period prevalent cases include the number of cases that existed at the begining of the time period(1996/97) in addition to all new cases that develop during the period of 1996/97-2006/07*

The Public Health Agency of Canada's National Diabetes Surveillance System (NDSS) algorithm - at least one hospital discharge or two physician visits in a moving 730 day (2-year) period with the relevant diabetes code.

Current Results

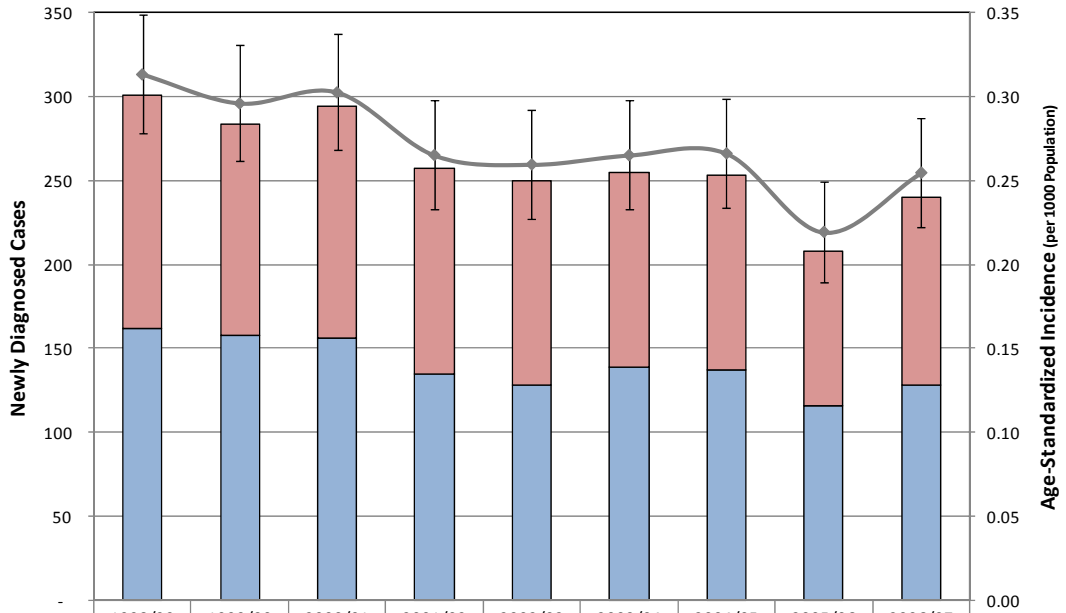
Incidence

Type 1

The trend in both the number of newly diagnosed cases and the incidence of T1DM in British Columbia is indicated in Figure 3. In 2006/07, 240 B.C. children (112 females and 128 males) were diagnosed with T1DM, for an incidence of 0.255 cases for every 1,000 children. The rate for females is slightly lower at 0.244 than for males (0.264). It is important to remember that there is unknown period of time that is required to achieve a steady state within administrative data. We feel the decrease in incidence of T1DM from 1998/99 to 2001/02 is the result of an "administrative delay" in the case-finding definition picking up incident cases of T1DM. If we assume a steady state is achieved in 2001/2002, the trend indicates minimal variation in the annual incidence of T1DM up until 2006/2007. Ongoing surveillance is required to clarify the overall trend in incidence of T1DM in children living in BC.

Figure 3. Type 1 Paediatric Diabetes in British Columbia

Newly Diagnosed Cases and Age-Standardized Incidence (per 1000 Population)
1998/99 - 2006/07



	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	139	125	138	122	122	116	116	92	112
Males	162	158	156	135	128	139	137	116	128
Incidence (per 1000 Pop)	0.313	0.296	0.303	0.265	0.260	0.265	0.266	0.219	0.255

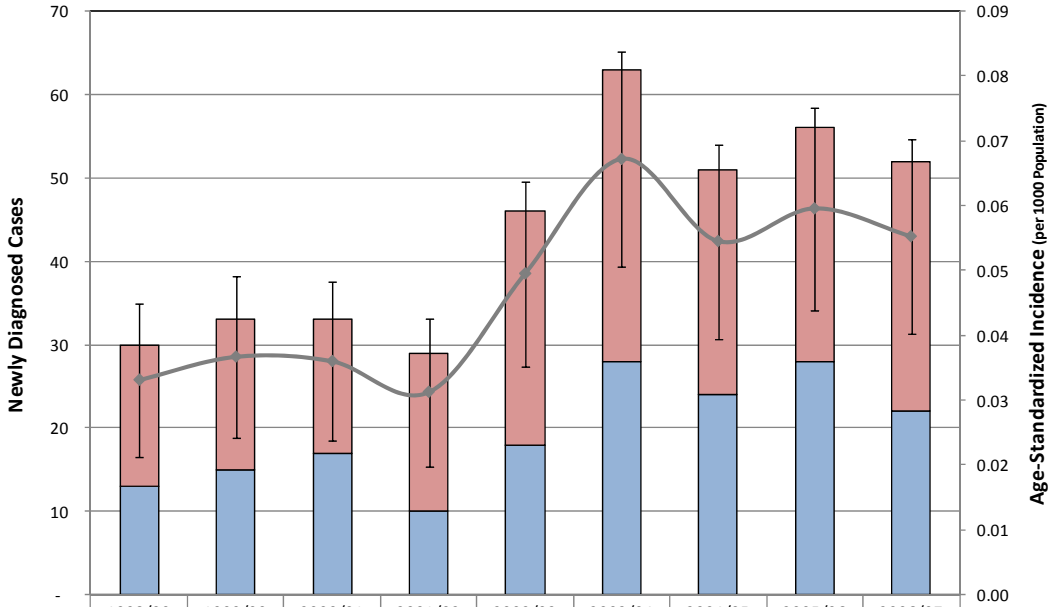
Fiscal Year

Type 2

The trend in both the number of newly diagnosed cases and the incidence rate of T2DM in British Columbia is indicated in Figure 4. The number of B.C. children with diagnosed incident T2DM appears to be increasing, from 30 in 1998/99 to 52 in 2006/07, although this increase is not statistically significant. The 52 incident cases in 2006/07 consisted of 30 females and 22 males, with a rate in females of 0.066 cases per 1,000 and a rate in males of 0.045. Based on this data and published reports indicating an increase in T2DM among children, it is likely that the incidence of childhood T2DM is increasing in BC. Again, ongoing surveillance is critical to better understand the overall trend.

Figure 4. Type 2 Paediatric Diabetes in British Columbia

Newly Diagnosed Cases and Age-Standardized Incidence (per 1000 Population)
1998/99 - 2006/07



	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	17	18	16	19	28	35	27	28	30
Males	13	15	17	10	18	28	24	28	22
Incidence (per 1000 Pop)	0.033	0.037	0.036	0.031	0.049	0.067	0.054	0.059	0.055

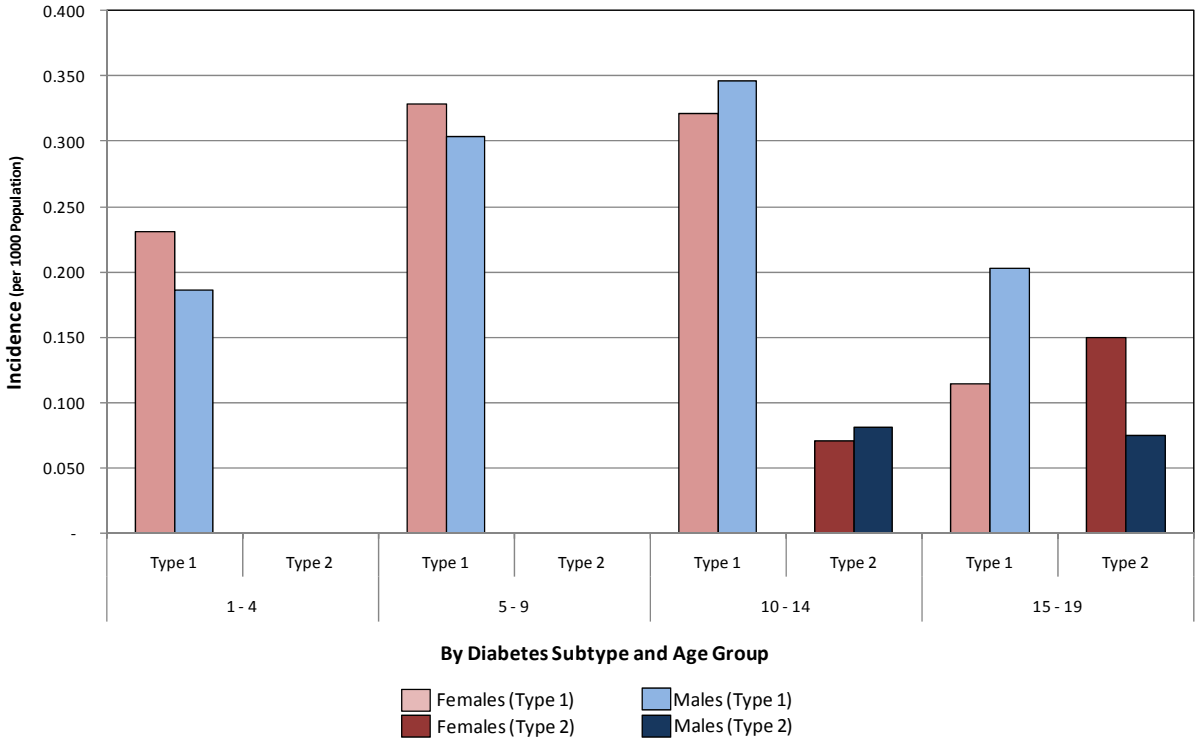
Fiscal Year

By Age Group

The incidence of T1DM in B.C. in 2006/07 increased from 0.208 per 1,000 population in young children (1-4 years of age) to 0.316 for 5-9 years olds and 0.335 for 10-14 year olds before declining to 0.160 for 15-19 years olds. In the older teen group, the rate of T2DM approached that of T1DM. In fact, for females, the rate of 0.150 per 1,000 population for T2DM is higher than the rate for T1DM, at 0.115 (see Figure 5).

Figure 5. Paediatric Diabetes in British Columbia

Type 1 and Type 2 Incidence (per 1000 Population)
by Age Group and Gender, 2006/2007



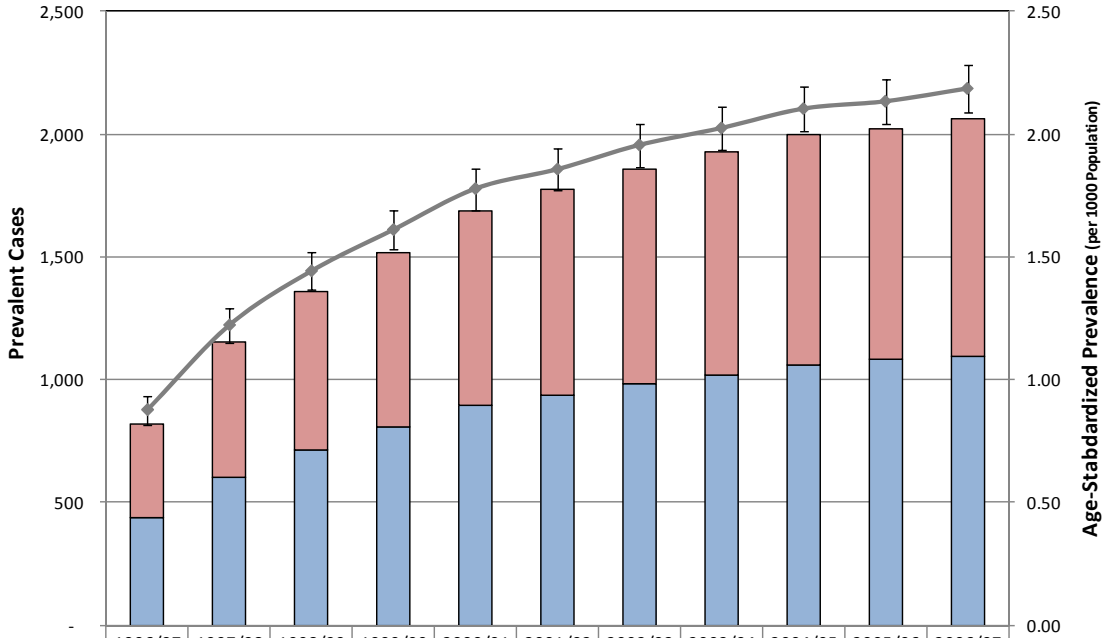
Prevalence

Type 1

In 1996/97, a total of 817 paediatric T1DM cases were identified by the algorithm. This increased to 2,064 in 2006/07. While ideally the initial year or two of a surveillance system should pick-up all existing cases in the population, in reality the run-in period is longer than this before a 'steady-state' is achieved. Based on the information in Figure 6, this steady-state may take at least 5-7 years. Further, the increasing prevalence may also be the result of low mortality rates among this cohort.

Figure 6. Type 1 Paediatric Diabetes in British Columbia

Prevalent Cases and Age-Standardized Prevalence (per 1000 Population)
1997/98 - 2006/07



	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	380	550	646	708	791	837	873	913	936	942	967
Males	437	600	715	809	896	938	983	1,016	1,061	1,080	1,097
Prevalence (per 1000 Pop)	0.876	1.221	1.441	1.610	1.777	1.856	1.955	2.024	2.103	2.133	2.185

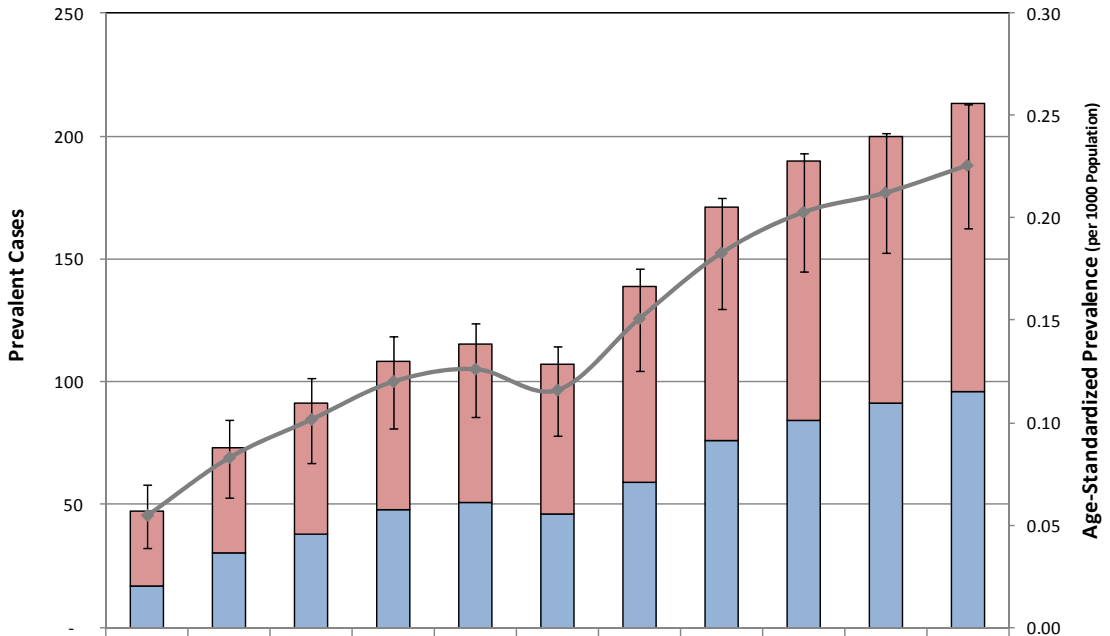
Fiscal Year

Type 2

In 1996/97, a total 47 paediatric T2DM cases were identified by the algorithm, increasing to 213 in 2006/07. As with the noted increase in T1DM, this increase is likely due to combination of a run-in period and a true increase in incidence.

Figure 7. Type 2 Paediatric Diabetes in British Columbia

Prevalent Cases and Age-Standardized Prevalence (per 1000 Population)
1997/98 - 2006/07



	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	30	43	53	60	64	61	80	95	106	109	117
Males	17	30	38	48	51	46	59	76	84	91	96
Prevalence (per 1000 Pop)	0.054	0.083	0.101	0.120	0.126	0.116	0.151	0.183	0.203	0.212	0.225

Fiscal Year

Incidence by Geographic Location of the Patient

Type 1

As part of the process to determine whether there was any difference in the age-standardized incidence rate based on the geographic location of the patient (at the time of diagnosis) in B.C., the most recent five-years of results (2002/03 to 2006/07) were aggregated. The results for T1DM by Health Authority (HA) and Health Services Delivery Area (HSDA) are shown in Table 4 and Figures 8 and 9.

Compared to the provincial aggregate incidence over this time period of 0.253 per 1,000 population, the incidence in Richmond (0.156) and Vancouver (0.190) HSDAs were significantly below the provincial aggregate. While a number of HSDAs showed an incidence above the provincial aggregate, only the Thompson Cariboo HSDA, at 0.345, was significantly so.

Table 4: Type 1 Pediatric Diabetes in British Columbia
Age-standardized Incidence Rates (per 1,000 population)
by Gender and Geographic Location of the Patient
Five-Year Aggregate (2002/03 to 2007/08)

Health Authority / Health Services Delivery Area	Males			Females			Total		
	Incidence Rate	95% CI		Incidence Rate	95% CI		Incidence Rate	95% CI	
Fraser Total	**0.263**	**0.297**	**0.230**	**0.243**	**0.276**	**0.210**	**0.253**	**0.277**	**0.230**
Fraser East	0.325	0.412	0.239	0.283	0.366	0.200	0.305	0.365	0.245
Fraser North	0.219	0.270	0.167	0.240	0.296	0.185	0.229	0.267	0.192
Fraser South	0.275	0.326	0.224	0.230	0.278	0.183	0.253	0.288	0.218
Vancouver Coastal Total	**0.219**	**0.260**	**0.178**	**0.189**	**0.228**	**0.150**	**0.204**	**0.233**	**0.176**
Richmond	0.153	0.228	0.078	0.159	0.240	0.079	0.156	0.212	0.101
Vancouver	0.193	0.246	0.139	0.188	0.242	0.133	0.190	0.228	0.152
North Shore/Coast Garibaldi	0.305	0.394	0.216	0.215	0.292	0.138	0.261	0.320	0.202
Vancouver Island Total	**0.297**	**0.352**	**0.241**	**0.242**	**0.294**	**0.191**	**0.270**	**0.308**	**0.232**
South Vancouver Island	0.241	0.316	0.167	0.234	0.309	0.160	0.238	0.291	0.185
Central Vancouver Island	0.339	0.437	0.241	0.296	0.391	0.202	0.318	0.386	0.250
North Vancouver Island	0.345	0.486	0.204	0.160	0.259	0.061	0.254	0.340	0.167
Interior Total	**0.317**	**0.373**	**0.260**	**0.305**	**0.362**	**0.248**	**0.311**	**0.351**	**0.271**
East Kootenay*	0.141	0.253	0.028	0.394	0.587	0.201	0.265	0.376	0.154
Kootenay Boundary*	0.289	0.452	0.125	0.083	0.176	-0.011	0.190	0.286	0.094
Okanagan	0.355	0.443	0.266	0.297	0.380	0.215	0.326	0.387	0.266
Thompson Cariboo	0.333	0.435	0.231	0.357	0.465	0.249	0.345	0.419	0.270
Northern Total	**0.285**	**0.361**	**0.210**	**0.272**	**0.347**	**0.197**	**0.279**	**0.333**	**0.226**
Northwest*	0.284	0.428	0.140	0.177	0.292	0.061	0.233	0.326	0.139
Northern Interior	0.284	0.391	0.177	0.324	0.442	0.206	0.304	0.383	0.224
Northeast*	0.292	0.451	0.133	0.272	0.426	0.118	0.282	0.392	0.171
BC Total	**0.265**	**0.285**	**0.244**	**0.240**	**0.260**	**0.220**	**0.253**	**0.267**	**0.239**

* Based on a sample size of < 30.

Figure 8. Type 1 Pediatric Diabetes in British Columbia

Age-Standardized Incidence Rates (per 1,000 population)
Five-Year Aggregate (2002/03 - 2006/07)
by Geographic Location of the Patient (Health Authority and Health Service Delivery Area)

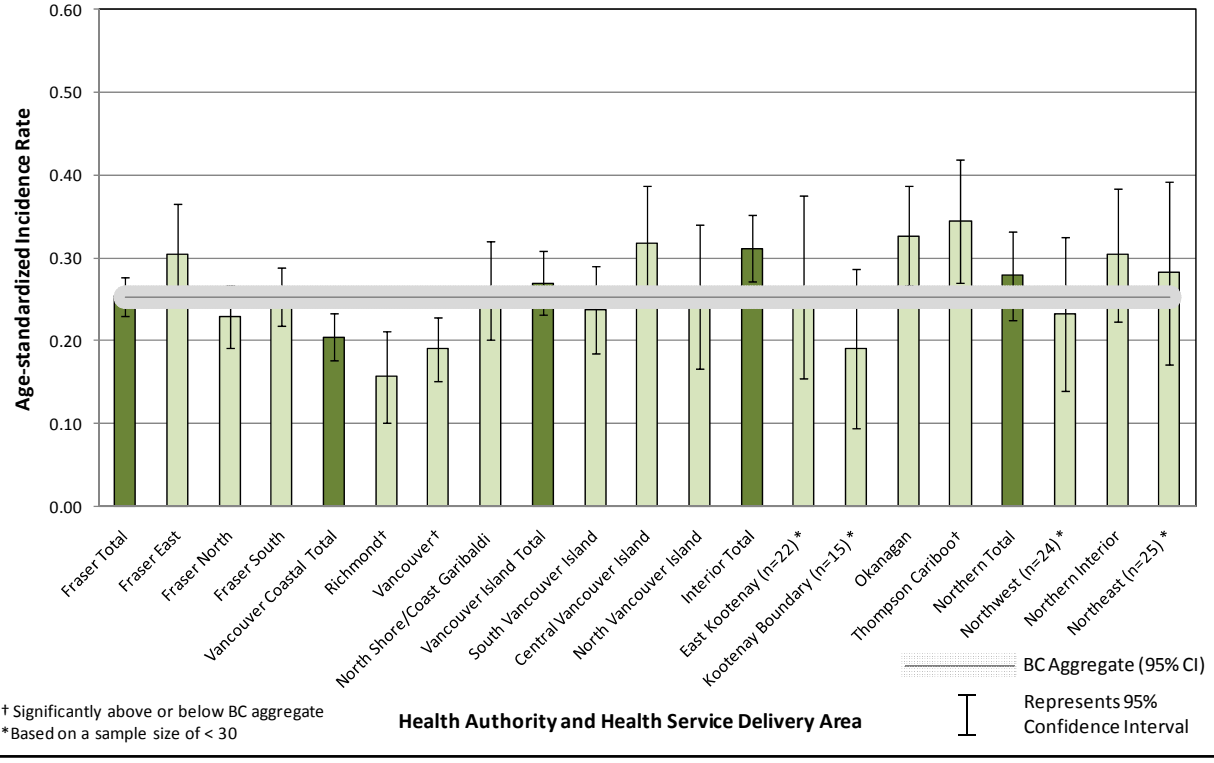
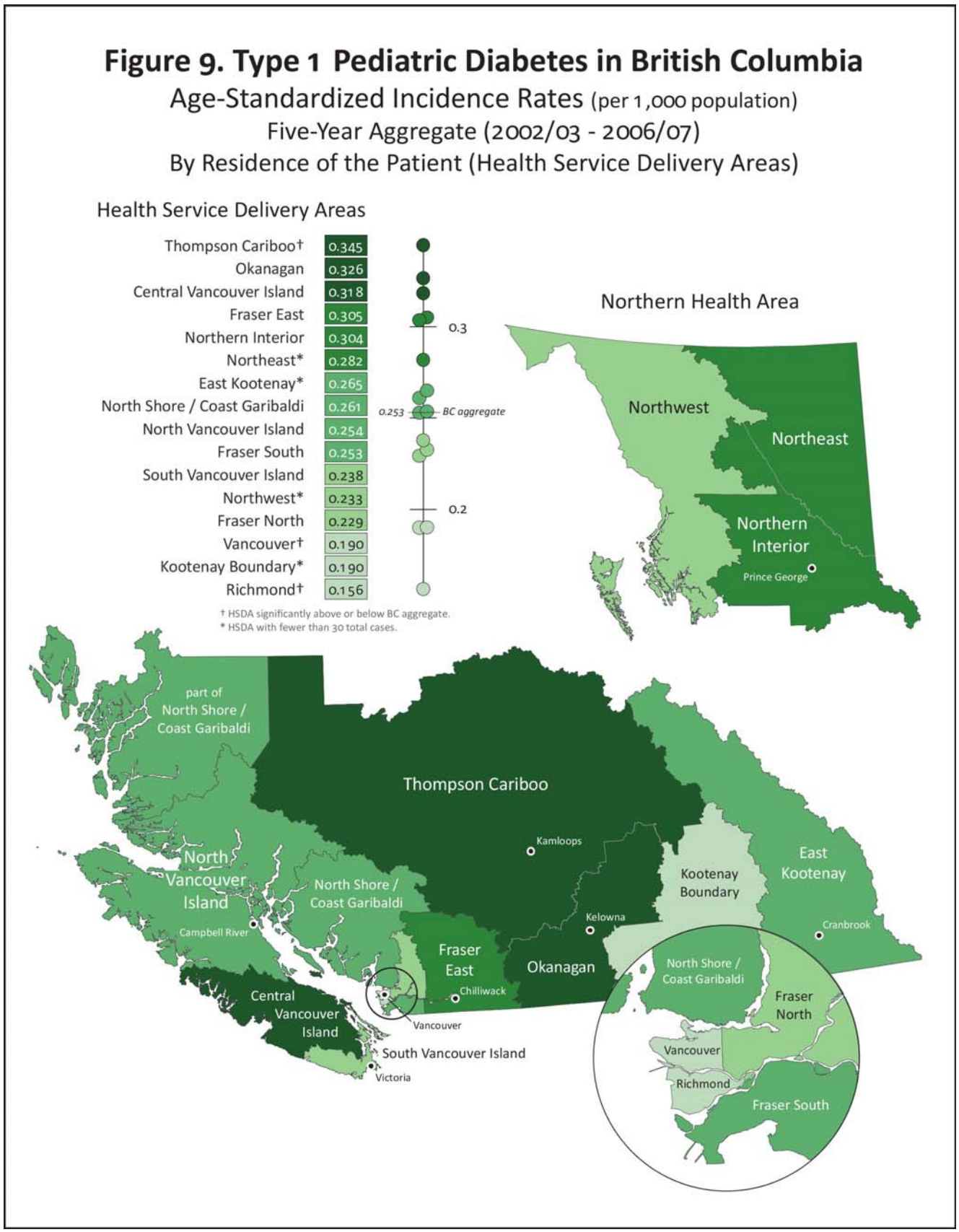


Figure 9. Type 1 Pediatric Diabetes in British Columbia

Age-Standardized Incidence Rates (per 1,000 population)
Five-Year Aggregate (2002/03 - 2006/07)
By Residence of the Patient (Health Service Delivery Areas)



Type 2

The results for a similar aggregation for T2DM by HA are shown in Table 5 and Figure 10. The volume of pediatric T2DM cases is too small for meaningful comparisons by HSDA.

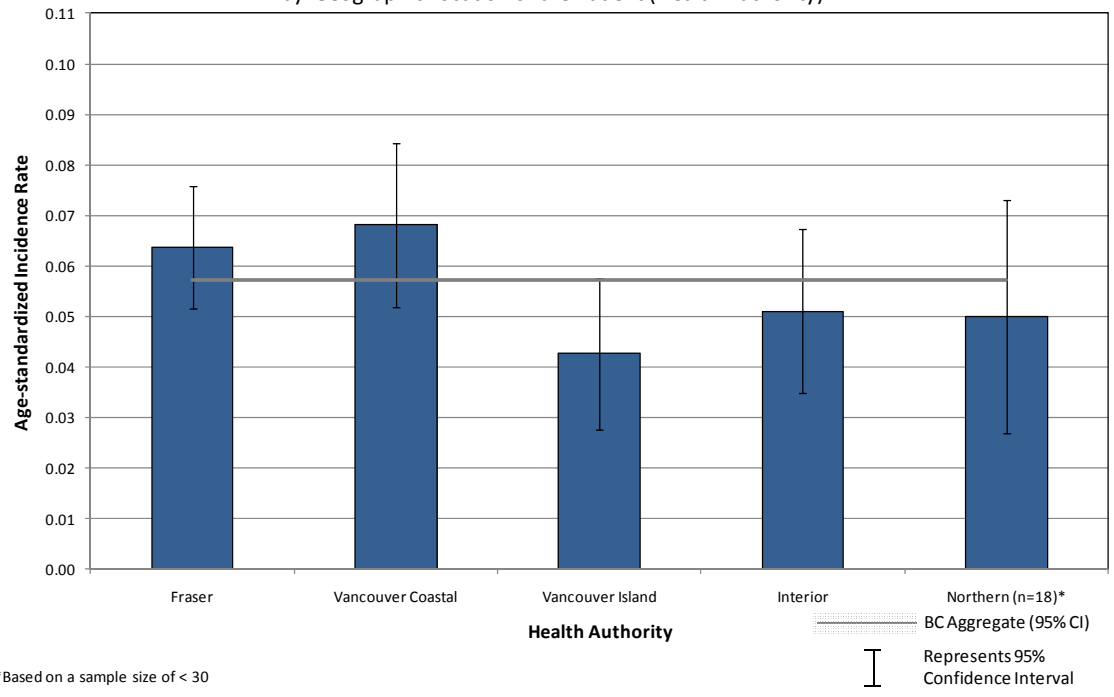
Based on this available information, no significant differences exist in the incidence of T2DM by geographic location in B.C.

Table 5. Type 2 Pediatric Diabetes in British Columbia
Age-standardized Incidence Rates (per 1,000 population)
Five-Year Aggregate (2002/03 to 2007/08)
by Gender and Geographic Location of the Patient

Health Authority	Males			Females			Total		
	Incidence Rate	95% CI		Incidence Rate	95% CI		Incidence Rate	95% CI	
Fraser	0.051	0.066	0.036	0.077	0.096	0.058	0.064	0.076	0.052
Vancouver Coastal	0.073	0.096	0.049	0.063	0.086	0.041	0.068	0.084	0.052
Vancouver Island	0.044	0.065	0.022	0.042	0.063	0.021	0.043	0.058	0.028
Interior	0.026	0.042	0.010	0.077	0.106	0.049	0.051	0.067	0.035
Northern*	0.049	0.081	0.017	0.051	0.084	0.018	0.050	0.073	0.027
BC Total	0.050	0.059	0.041	0.065	0.075	0.055	0.057	0.064	0.050

* Based on a sample size of < 30.

Figure 10. Type 2 Pediatric Diabetes in British Columbia
Age-Standardized Incidence Rates (per 1,000 population)
Five-Year Aggregate (2002/03 - 2006/07)
by Geographic Location of the Patient (Health Authority)



Summary and Next Steps

To reiterate, the research targets of the present project comprise the following questions:

1. What is paediatric diabetes in BC?
2. What is the quality of paediatric diabetes care in BC?
3. What are the consequences of paediatric diabetes?

Information related to the first question has been the main focus of this initial report.

Based on the case-finding definition and diabetes classification algorithm derived and adopted for this report, there have been 4,019 incident paediatric diabetes cases in the province between 1996/97 and 2006/07, with 3,546 (88.2%) identified as T1DM and 473 (11.8%) as T2DM.

A combination of steady or growing incidence and relatively low mortality means that the pool of paediatric patients is also increasing steadily. This has implications for the ongoing burden of health care in the short term. The next steps in the project naturally turn to the topic of the quality of care received by these paediatric patients.

One of the next steps will be to identify indicators of process and health outcomes in children and youth with paediatric diabetes in order to describe the present quality of health care services provided to this population. More specifically, the objective is to assess the extent to which quality of care indicators derived from administrative databases provide valid and useful information for assessing evidence-based clinical practice.

Appendix A: Algorithm Assumptions

Algorithms for validation were developed based on the following demographic assumptions:

Assumption #1: An Aboriginal status flag suggests T2DM.

Rationale: Almost all Aboriginal people with diabetes (children and adults) have T2DM. That is, T1DM is exceedingly uncommon in this population. This has been shown in many Aboriginal populations including the Pima Indians of Arizona,[33]the Navajo people in the Southern U.S.,[34]Aboriginal people in Australia,[35] and Aboriginal people in Manitoba.[36,37]Therefore, any paediatric diabetes patient identified as 'Aboriginal status' was assumed to have T2DM.

Drug utilization patterns: In cases with an Aboriginal status flag, 52% used insulin and glucose strips and 14.3% used insulin and glucose strips in combination with metformin. Both these drug utilization patterns may be consistent with a diagnosis of T2DM, as demonstrated in the work of Amed et al. indicating that approximately 50% of children with T2DM are started on insulin at diagnosis.[38]

Assumption #2: **Those who are not Aboriginal status and <10 years of age are likely T1DM.**

Rationale: T2DM is extremely rare in children under the age of 10 since it is typically associated with the peri-pubertal or pubertal child. The exception may be Aboriginal children, but these have already been identified as T2DM based on the first assumption. Consequently, the second assumption is that all children who are less than 10 years of age and non-status Aboriginal have T1DM.

Drug utilization patterns: 95% of cases with these demographic characteristics had a drug utilization pattern of insulin plus glucose monitoring strips – a pattern that is most consistent with a diagnosis of T1DM.

Neither of these assumptions is perfect as the occasional status Aboriginal child may have T1DM and the occasional non-status Aboriginal child under the age of 10 may have T2DM. These exceptions, however, were expected to be rare.

Table 6 indicates the most common drug utilization patterns identified among cases, as well as the most likely diabetes type associated with each drug utilization pattern based on clinical expertise.

[33] Dabelea D, Hanson RL, Bennett PH et al. Increasing prevalence of Type II diabetes in American Indian children. *Diabetologia.* 1998; 41(8): 904-10.
[34] Dabelea D, DeGroat J, Sorrelman C et al. Diabetes in Navajo youth: prevalence, incidence, and clinical characteristics: the SEARCH for Diabetes in Youth Study. *Diabetes Care.* 2009; 32 Suppl 2: S141-7.
[35] de Courten, Hodge M, Dowse A et al. *Review of the Epidemiology, Aetiology, Pathogenosis and Preventability of Diabetes in Aboriginal and Torres Strait Islander Populations, Office for Aboriginal and Torres Islander Health, Commonwealth Department of Health and Family Services*. Canberra: 1998.
[36] Dean HJ, Mundy RL, Moffatt M. Non-insulin-dependent diabetes mellitus in Indian children in Manitoba. *Canadian Medical Association Journal.* 1992; 147(1): 52-7.
[37] Dean HJ, Young TK, Flett B et al. Screening for type-2 diabetes in aboriginal children in northern Canada. *Lancet.* 1998; 352(9139): 1523-4.
[38] Amed S, Dean HJ, Panagiotopoulos C et al. Type 2 diabetes, medication-induced diabetes, and monogenic diabetes in Canadian children: a prospective national surveillance study. *Diabetes Care.* 2010; 33(4): 786-91.

Table 6. Common Drug Utilization Patterns Identified Among Paediatric Diabetes Cases

Drug Utilization Pattern	*Most Likely Diabetes Type*	*Comments (Based on Clinical Experience and Detailed Analysis of Data)*
INSULIN ONLY INSULIN + GLUCOSE TESTING STRIPS	T1DM	All children with T1DM will require insulin therapy. The lack of a oral hypoglycaemic agent decreases the potential of a diagnosis of T2DM
INSULIN + GLUCOSE TESTING STRIPS + METFORMIN	T1DM OR T2DM	Some T1DM patients are started on metformin because of insulin resistance during puberty and the presence of obesity. Insulin therapy in combination with metformin is also commonly used in children with T2DM. Further analysis of the cases with this drug utilization pattern indicated that 49% filled only 1-2 prescriptions for metformin whereas 78% had ≥20 prescriptions for insulin indicating insulin was the predominant therapy.
INSULIN + METFORMIN + OTHER ORAL AGENTS +/- GLUCOSE TESTING STRIPS	T2DM	The presence of other oral hypoglycaemic agents increased the liklihood of a diagnosis of T2DM
METFORMIN +/- ORAL AGENTS +/- GLUCOSE TESTING STRIPS OTHER ORAL AGENTS ONLY GLUCOSE TESTING STRIPS ONLY	T2DM	The absence of insulin therapy eliminated T1DM as a possible diagnosis

Appendix B: Incidence and Prevalence of Paediatric Diabetes in B.C.

The NDSS case-finding definition requires a two year B.C. residency. This requirement, together with the identification of both prevalent and incident cases in the first year (1996/97), suggests that the cases in the first two years are not necessarily 'newly diagnosed' or incident cases. While the numbers for these two years are presented, they are 'greyed out' to highlight this fact.

Newly Diagnosed Paediatric T1DM Cases in British Columbia
1998/99 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Females	380	193	139	125	138	122	122	116	116	92	112	1655
Males	437	195	162	158	156	135	128	139	137	116	128	1891
Total	**817**	**388**	**301**	**283**	**294**	**257**	**250**	**255**	**253**	**208**	**240**	**3546**

Paediatric T1DM Incidence in British Columbia
Age-Standardized Rate / 1,000 Population

Females	0.834	0.419	0.295	0.269	0.291	0.259	0.259	0.249	0.251	0.199	0.244	
95% CI	0.919	0.479	0.344	0.316	0.339	0.305	0.305	0.294	0.296	0.240	0.289	
	0.750	0.360	0.246	0.222	0.242	0.213	0.213	0.203	0.205	0.159	0.199	
Males	0.915	0.399	0.330	0.322	0.314	0.271	0.260	0.281	0.281	0.238	0.264	
95% CI	1.001	0.455	0.381	0.372	0.363	0.317	0.305	0.327	0.328	0.282	0.310	
	0.829	0.342	0.279	0.271	0.264	0.225	0.215	0.234	0.234	0.195	0.219	
Total	**0.876**	**0.409**	**0.313**	**0.296**	**0.303**	**0.265**	**0.260**	**0.265**	**0.266**	**0.219**	**0.255**	
95% CI	**0.936**	**0.449**	**0.349**	**0.331**	**0.337**	**0.298**	**0.292**	**0.298**	**0.299**	**0.249**	**0.287**	
	0.815	**0.368**	**0.278**	**0.261**	**0.268**	**0.233**	**0.227**	**0.233**	**0.233**	**0.189**	**0.222**	

Newly Diagnosed Paediatric T2DM Cases in British Columbia
1998/99 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Females	30	17	17	18	16	19	28	35	27	28	30	265
Males	17	16	13	15	17	10	18	28	24	28	22	208
Total	**47**	**33**	**30**	**33**	**33**	**29**	**46**	**63**	**51**	**56**	**52**	**473**

Paediatric T2DM Incidence in British Columbia
Age-Standardized Rate / 1,000 Population

Females	0.072	0.040	0.038	0.041	0.036	0.042	0.062	0.077	0.059	0.061	0.066	
95% CI	0.097	0.059	0.057	0.060	0.054	0.061	0.085	0.102	0.082	0.084	0.089	
	0.046	0.021	0.020	0.022	0.018	0.023	0.039	0.051	0.037	0.039	0.042	
Males	0.038	0.035	0.028	0.033	0.036	0.021	0.038	0.058	0.050	0.058	0.045	
95% CI	0.056	0.053	0.043	0.049	0.053	0.034	0.055	0.080	0.070	0.079	0.064	
	0.020	0.018	0.013	0.016	0.019	0.008	0.020	0.037	0.030	0.036	0.026	
Total	**0.054**	**0.037**	**0.033**	**0.037**	**0.036**	**0.031**	**0.049**	**0.067**	**0.054**	**0.059**	**0.055**	
95% CI	**0.070**	**0.050**	**0.045**	**0.049**	**0.048**	**0.043**	**0.064**	**0.084**	**0.069**	**0.075**	**0.070**	
	0.039	**0.025**	**0.021**	**0.024**	**0.024**	**0.020**	**0.035**	**0.051**	**0.040**	**0.044**	**0.040**	

Newly Diagnosed Paediatric Diabetes Cases in British Columbia
1998/99 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
Females	410	210	156	143	154	141	150	151	143	120	142	1,920
Males	454	211	175	173	173	145	146	167	161	144	150	2,099
Total	**864**	**421**	**331**	**316**	**327**	**286**	**296**	**318**	**304**	**264**	**292**	**4,019**

Paediatric Diabetes Incidence in British Columbia
Age-Standardized Rate / 1,000 Population

Females	0.906	0.459	0.334	0.310	0.327	0.301	0.321	0.325	0.310	0.260	0.310	
95% CI	0.994	0.521	0.386	0.361	0.378	0.351	0.372	0.377	0.361	0.307	0.361	
	0.818	0.397	0.281	0.259	0.275	0.251	0.269	0.273	0.259	0.214	0.259	
Males	0.953	0.434	0.358	0.354	0.350	0.292	0.298	0.339	0.330	0.296	0.310	
95% CI	1.041	0.493	0.412	0.407	0.402	0.339	0.346	0.390	0.382	0.344	0.359	
	0.865	0.375	0.305	0.301	0.298	0.244	0.250	0.287	0.279	0.248	0.260	
Total	**0.930**	**0.446**	**0.346**	**0.333**	**0.338**	**0.296**	**0.309**	**0.332**	**0.321**	**0.279**	**0.310**	
95% CI	**0.992**	**0.489**	**0.384**	**0.369**	**0.375**	**0.331**	**0.344**	**0.369**	**0.357**	**0.312**	**0.345**	
	0.868	**0.403**	**0.309**	**0.296**	**0.302**	**0.262**	**0.274**	**0.296**	**0.285**	**0.245**	**0.274**	

Prevalent Paediatric T1DM Cases in British Columbia

1996/97 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	380	550	646	708	791	837	873	913	936	942	967
Males	437	600	715	809	896	938	983	1,016	1,061	1,080	1,097
Total	**817**	**1,150**	**1,361**	**1,517**	**1,687**	**1,775**	**1,856**	**1,929**	**1,997**	**2,022**	**2,064**

Paediatric T1DM Prevalence in British Columbia

Age-Standardized Rate / 1,000 Population

Females	0.834	1.200	1.403	1.544	1.710	1.798	1.890	1.970	2.027	2.044	2.105
95% CI	0.919	1.300	1.512	1.658	1.829	1.920	2.016	2.098	2.157	2.174	2.238
	0.750	1.099	1.295	1.430	1.591	1.676	1.765	1.842	1.898	1.913	1.973
Males	0.915	1.241	1.477	1.672	1.840	1.911	2.016	2.075	2.174	2.217	2.260
95% CI	1.001	1.341	1.586	1.787	1.960	2.034	2.142	2.202	2.305	2.349	2.394
	0.829	1.141	1.369	1.557	1.719	1.789	1.890	1.947	2.043	2.085	2.127
Total	**0.876**	**1.221**	**1.441**	**1.610**	**1.777**	**1.856**	**1.955**	**2.024**	**2.103**	**2.133**	**2.185**
95% CI	**0.936**	**1.292**	**1.518**	**1.691**	**1.861**	**1.943**	**2.044**	**2.114**	**2.195**	**2.226**	**2.279**
	0.815	**1.150**	**1.364**	**1.528**	**1.692**	**1.770**	**1.866**	**1.933**	**2.010**	**2.040**	**2.091**

Prevalent Paediatric T2DM Cases in British Columbia

1996/97 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	30	43	53	60	64	61	80	95	106	109	117
Males	17	30	38	48	51	46	59	76	84	91	96
Total	**47**	**73**	**91**	**108**	**115**	**107**	**139**	**171**	**190**	**200**	**213**

Paediatric T2DM Prevalence in British Columbia

Age-Standardized Rate / 1,000 Population

Females	0.072	0.100	0.121	0.136	0.144	0.136	0.178	0.209	0.233	0.238	0.255
95% CI	0.097	0.130	0.154	0.171	0.179	0.170	0.217	0.250	0.277	0.282	0.301
	0.046	0.070	0.089	0.102	0.109	0.102	0.139	0.167	0.188	0.193	0.209
Males	0.038	0.066	0.082	0.104	0.109	0.097	0.125	0.158	0.174	0.188	0.198
95% CI	0.056	0.089	0.108	0.133	0.138	0.125	0.156	0.194	0.211	0.226	0.237
	0.020	0.042	0.056	0.075	0.079	0.069	0.093	0.123	0.137	0.149	0.158
Total	**0.054**	**0.083**	**0.101**	**0.120**	**0.126**	**0.116**	**0.151**	**0.183**	**0.203**	**0.212**	**0.225**
95% CI	**0.070**	**0.102**	**0.122**	**0.142**	**0.149**	**0.138**	**0.176**	**0.210**	**0.231**	**0.242**	**0.256**
	0.039	**0.064**	**0.080**	**0.097**	**0.103**	**0.094**	**0.126**	**0.155**	**0.174**	**0.183**	**0.195**

Prevalent Paediatric Diabetes Cases in British Columbia

1996/97 to 2006/07

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Females	410	593	699	768	855	898	953	1,008	1,042	1,051	1,084
Males	454	630	753	857	947	984	1,042	1,092	1,145	1,171	1,193
Total	**864**	**1,223**	**1,452**	**1,625**	**1,802**	**1,882**	**1,995**	**2,100**	**2,187**	**2,222**	**2,277**

Paediatric Diabetes Prevalence in British Columbia

Age-Standardized Rate / 1,000 Population

Females	0.906	1.300	1.525	1.680	1.854	1.934	2.068	2.178	2.260	2.282	2.360
95% CI	0.994	1.405	1.638	1.799	1.979	2.060	2.200	2.313	2.397	2.420	2.501
	0.818	1.195	1.411	1.561	1.730	1.807	1.937	2.044	2.123	2.144	2.220
Males	0.953	1.307	1.559	1.776	1.948	2.008	2.140	2.233	2.348	2.405	2.458
95% CI	1.041	1.409	1.671	1.895	2.072	2.133	2.270	2.365	2.484	2.543	2.598
	0.865	1.204	1.448	1.657	1.824	1.882	2.010	2.100	2.212	2.267	2.319
Total	**0.930**	**1.303**	**1.543**	**1.729**	**1.902**	**1.972**	**2.105**	**2.206**	**2.305**	**2.345**	**2.410**
95% CI	**0.992**	**1.377**	**1.622**	**1.814**	**1.990**	**2.061**	**2.198**	**2.301**	**2.402**	**2.442**	**2.509**
	0.868	**1.230**	**1.463**	**1.645**	**1.814**	**1.883**	**2.013**	**2.112**	**2.209**	**2.247**	**2.311**