

High Incidence of Childhood Type 1 Diabetes in the Avalon Peninsula, Newfoundland, Canada

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OBJECTIVE — The aim of this study was to determine the incidence of type 1 diabetes among children aged 0–14 years in the Avalon Peninsula in the Canadian Province of Newfoundland.

RESEARCH DESIGN AND METHODS — This was a prospective cohort study of the incidence of childhood type 1 diabetes in children aged 0–14 years who were diagnosed with type 1 diabetes from 1987 to 2002 on the Avalon Peninsula. Identified case subjects during this time period were ascertained from several sources and verified using the capture-recapture technique. Data were obtained from the only pediatric diabetes treatment center for children living on the Avalon Peninsula.

RESULTS — Over the study period, 294 children aged 0–14 years from the Avalon Peninsula were diagnosed with type 1 diabetes. The incidence of type 1 diabetes in this population over the period 1987–2002 inclusive was 35.93 with a 95% CI of 31.82–40.03. The incidence over this period increased linearly at the rate of 1.25 per 100,000 individuals per year.

CONCLUSIONS — The Avalon Peninsula of Newfoundland has one of the highest incidences of type 1 diabetes reported worldwide. The incidence increased over the 16-year study period.

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Type 1 diabetes, the most common form of diabetes in childhood, is a T-cell-mediated autoimmune disease in which both genetic and environmental factors play roles in the etiology (1,2). The incidence of childhood type 1 diabetes is known to vary widely between and within countries. The incidence of type 1 diabetes (≤ 14 years) varies from 0.1/100,000 per year in China (1990–1994) and Venezuela (1992) to 36.8/100,000 per year in Sardinia (1990–1994) and 36.5/100,000 per year in

Finland (1990–1994) (3). In most populations the incidence has been increasing (4). The incidence of type 1 diabetes in Canada is available from only a few studies, which were carried out over the past 25 years (3,5–7). Two Canadian provinces have also reported a high incidence of the disease. A 6-year study (1990–1995) reported a mean incidence of 25.7/100,000 in children < 15 years of age who lived in the city of Edmonton (5). A 4-year study from the province of Prince Edward Island reported a mean incidence of 24.5/

100,000 in children < 15 years of age (1990–1993) (3). The reported mean incidence for Montreal (1971–1985) among children 0–14 years was 10.1/100,000 (6). The lowest reported incidence was from Toronto (1976–1978) with a mean incidence of 9.0/100,000 per year in children < 19 years of age (7).

The study we are reporting was performed at the Janeway Child Health Care Centre (JCHCC), which is the only tertiary care children's hospital servicing the Province of Newfoundland and Labrador. All children with type 1 diabetes who live on the Avalon Peninsula are referred to one of the diabetologists at the JCHCC and are followed from the time of diagnosis by the Janeway Pediatric Diabetes Team. The Avalon Peninsula was chosen for a study of the incidence of diabetes because it is well defined geographically and because all children from this area are followed at a single diabetes clinic. This enabled us to have confidence about the degree of ascertainment achieved. Also, 46% of the childhood population of Newfoundland lives on the Avalon Peninsula (8).

RESEARCH DESIGN AND METHODS

The Memorial University of Newfoundland and Health Care Corporation of St. John's Ethics Committees approved this study.

Case ascertainment

From 1987 to 2002, all newly diagnosed children with type 1 diabetes were admitted to the Janeway Hospital and were subsequently followed at the Hospital Clinic. Subjects included in this study were ascertained from three sources. First, subjects were ascertained from the diabetes register for type 1 diabetes, which was kept at the Janeway Hospital by the diabetes nurse educator from 1987 onward. Next, research nurses carried out a search of the Hospital Medical Records Department using the diagnostic index code for insulin-dependent diabetes from 1987 to 2002. Subjects were also ascertained from the office records of pediatricians who

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Abbreviations: JCHCC, Janeway Child Health Care Centre.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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Table 1—Incidence of type 1 diabetes (0–14 years) per 100,000 individuals in the Avalon Peninsula, Newfoundland, Canada, 1987–2002

Year	Sex	0–14 years	0–4 years	5–9 years	10–14 years
1987–2002	Boys and girls	35.93	24.95	37.01	43.62
1987–2002	Boys	36.15	28.65	35.23	42.83
1987–2002	Girls	35.69	21.13	38.85	44.46
1987–1991	Boys and girls	31.30	22.96	23.83	45.23
1992–1996	Boys and girls	32.68	23.29	40.74	32.80
1997–2001	Boys and girls	43.45	31.21	48.40	48.21
1987	Boys and girls	38.86	33.23	35.39	46.83
1988	Boys and girls	27.44	28.15	05.14	47.39
1989	Boys and girls	20.84	17.32	20.65	23.95
1990	Boys and girls	28.22	17.55	15.68	48.82
1991	Boys and girls	41.26	17.79	42.60	59.73
1992	Boys and girls	27.20	36.14	16.17	30.01
1993	Boys and girls	33.15	24.65	49.30	25.22
1994	Boys and girls	35.97	19.23	34.09	50.96
1995	Boys and girls	41.02	27.13	81.40	15.58
1996	Boys and girls	26.15	07.09	23.89	42.42
1997	Boys and girls	37.49	14.75	31.12	59.83
1998	Boys and girls	45.16	60.87	25.91	50.21
1999	Boys and girls	44.42	15.69	67.11	46.05
2000	Boys and girls	43.22	39.69	55.91	35.18
2001	Boys and girls	47.56	24.92	65.86	48.93
2002	Boys and girls	47.56	16.61	43.91	73.39

cared for patients with diabetes. Using the previous three sources, a master list of all patients with type 1 diabetes was established. The research nurse reviewed all charts obtained from the various sources described. Using a data abstraction form, basic demographic details were reported,

including a child's name and sex, date of birth, date of diagnosis, and address at diagnosis. The geographical address of the child at the time of diagnosis was recorded and confirmed to be located on the Avalon Peninsula.

Finally, a registry for the Provincial

Diabetes Camp was obtained from years 1987 to 2002 from the provincial diabetes camp director. All camp participants with addresses on the Avalon Peninsula were identified and matched to those from the master list compiled by the JCHCC research nurse. One hundred percent ascertainment was confirmed using the capture-recapture method.

Classification and case definition

The diagnosis of type 1 diabetes was confirmed based on current guidelines from the Canadian Diabetes Association classification of diabetes and diagnostic criteria (9). Patients included were those <15 years of age at the time of diagnosis. Patients excluded were those with type 2 diabetes, maturity-onset diabetes of youth, transient hyperglycemia, and diabetes caused by chemotherapy or cystic fibrosis. A small percentage of patients with diabetes diagnosed at <15 years of age have type 2 diabetes. Those patients are normally identified by the pediatric endocrinologist or diabetologist. Patients with suspected and confirmed type 2 diabetes were excluded. Although there are some First Nations patients followed at the JCHCC diabetes clinic from Labrador, there were none included in this study because they were not living on the Avalon Peninsula.

Incidence study population

The denominator for the analysis was children <15 years of age with residency in the study area that is defined geographically to correspond with census boundaries. The overall size of the population was obtained from census data (8), which are published by Statistics Canada, a department within the government of Canada. A national census performed every 5 years was undertaken in 1991, 1996, and 2001.

Statistical methods

The incidence was calculated as the number of newly diagnosed subjects per 100,000 individuals per year in the age-group 0–14 years and in 5-year age-groups (0–4, 5–9, and 10–14 years), and 95% CIs were calculated. Comparisons were made between boys and girls.

RESULTS — A total of 294 new cases of type 1 diabetes was identified among children ages 0–14 years during the study period. The overall incidence per

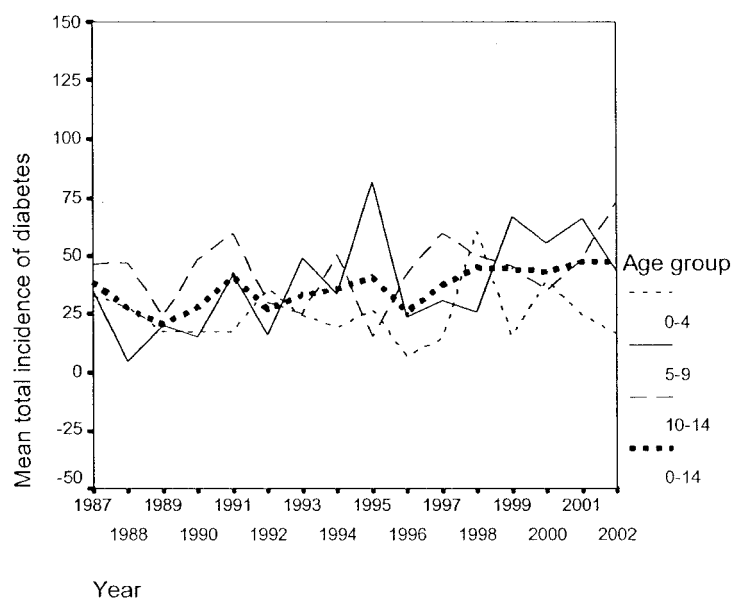


Figure 1—Incidence of type 1 diabetes per 100,000 individuals in the Avalon Peninsula, Newfoundland, Canada, from 1987 to 2002.

Table 2—Number of new cases of type 1 diabetes with midyear population for age-groups (0–4, 5–9, and 10–14 years) in the Avalon Peninsula, Newfoundland, Canada

	1987–1991	1992–1996	1997–2001	Total
Boys				
0–4 years				
New cases	13	10	12	35
Midyear population	44,266	39,212	32,508	115,986
5–9 years				
New cases	8	21	18	47
Midyear population	48,214	45,003	37,895	132,112
10–14 years				
New cases	16	21	21	58
Midyear population	53,901	49,776	44,443	148,120
0–14 years				
New cases	37	52	51	140
Midyear population	147,381	133,991	114,846	396,218
Girls				
0–4 years				
New cases	7	8	8	23
Midyear population	42,834	38,070	31,579	112,483
5–9 years				
New cases	15	15	18	48
Midyear population	47,297	43,356	36,530	127,183
10–14 years				
New cases	31	11	21	63
Midyear population	50,002	47,778	42,676	140,456
0–14 years				
New cases	53	34	47	134
Midyear population	140,133	129,204	110,785	380,122
Total				
0–4 years				
New cases	20	18	20	58
Midyear population	87,100	77,282	64,087	228,469
5–9 years				
New cases	23	36	36	95
Midyear population	86,511	88,359	74,425	259,295
10–14 years				
New cases	47	32	42	121
Midyear population	103,903	97,554	87,119	288,576
0–14 years				
New cases	90	86	98	274
Midyear population	287,514	263,195	225,631	776,340

100,000 individuals per year over the period 1987–2002 was 35.93 (95% CI 31.82–40.03) for the Avalon Peninsula, Newfoundland, Canada. See Table 1 for the mean incidences for the various age-groups between boys and girls.

There was no significant difference between the incidence of 36.15 for boys and 35.69 for girls during this 16-year period with a *P* value of 0.752. The corresponding *Z* score was -0.316 . The incidence per year for the age-group 0–14 years from 1998 to 2002 has remained $>40/100,000$ (Table 1). The linear re-

gression model fits well for the data of the incidence of boys and girls on years with $P < 0.01$. The value of the correlation coefficient between the total incidence and years is 0.7. The estimated rate at which the incidence is increasing per year in this population over the period 1987–2002 using the linear additive regression model is 1.25. The incidence for the 0- to 4-year age-group was 24.95, 5- to 9-year age-group was 37.01, and 10- to 14-year age-group was 43.62 per 100,000 (1987–2002) (Fig. 1).

CONCLUSIONS— This current study represents an analysis on the population from the Avalon Peninsula of Newfoundland, confirming the high and increasing incidence over the 16-year study period. The incidence has an increasing trend in all age-groups for both boys and girls (Table 2).

Worldwide, there is a wide variation in the incidence among various populations. In addition, there is a general increase in the incidence of type 1 diabetes in many European (10) and Middle-Eastern countries (4), which is confirmed in our population.

The current Newfoundland population is composed mainly of descendants from approximately 20,000 English and Irish immigrants who settled there in the mid-1700s (11). The cod fishery spurred the settlement of Newfoundland, which occurred particularly in the late 18th and early 19th centuries. Immigrants came from primarily two main areas, Southwest England and Southeast Ireland. By the mid-1830s, the major migrations had concluded, and the population of Newfoundland was approximately 75,000. After this, natural increase became the mechanism for population growth. Other factors, including geographic isolation, lack of roads, segregation by religion, and limited immigration kept related families together. In 1982, 50% of the population lived in communities $<2,500$ and 41% in communities of $<1,000$. The Newfoundland population can be considered to have relatively homogeneous origins as a result of how the population was settled and expanded (12). Founder effects have been identified in several other diseases in this population (13,14), and it is hypothesized that this may also be the case for type 1 diabetes, perhaps accounting for the high incidence in the Avalon Peninsula.

The incidence of type 1 diabetes in children aged <15 years on the Avalon Peninsula has been higher than in most areas of the world over the study duration. The incidence of type 1 diabetes has increased, especially over the last 5-year period. Environmental factors are suspected; however, these remain elusive. Although the etiology of type 1 diabetes is unknown, it is proposed that environmental factors may be at play in genetically susceptible individuals, triggering an immune response that leads to the destruction of the pancreatic β -cell. Envi-

ronmental factors hypothesized in the etiology of type 1 diabetes have included viruses, toxins, stressful life events, and dietary factors (15–20).

The early infant diet may be important. Breast-feeding for >3 months may be protective against type 1 diabetes (21). Breast-feeding has protective effects that reduce enteric infections early in life. Early introduction of cow's milk protein into an infants diet may possibly be harmful (18). Newfoundland has low rates of breast-feeding as compared with the rest of Canada; however, the rate of breast-feeding initiation has increased gradually over the same study period from 39 (1992) to 55.5% (2001) (22).

In conclusion, the Avalon Peninsula in Newfoundland appears to have the highest incidence of childhood type 1 diabetes in North America, with recent incidence approaching those of Finland and Sardinia. The high incidence is likely due to a combination of genetic and environmental factors. We are currently collecting incidence data from all diabetes centers across the province in a prospective manner. Continued research to determine the reasons for such a high incidence is warranted, and further study into this unique population may contribute to a better understanding of the etiology and pathogenesis of type 1 diabetes.

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