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Prevalence and Geographic Disparities in Certain Congenital Anomalies in Quebec: Comparison of Estimation Methods

Robert Choinière, Michel Pageau and Marc Ferland

Abstract

The purpose of this study was to estimate the prevalence of congenital anomalies in Quebec from MED-ECHO hospitalization records and from records of stillbirths. The results are first compared with those from the Canadian Congenital Anomalies Surveillance System (CCASS) for Quebec and Canada; then the data are examined by period and region of residence. The study results show that, for the congenital anomalies selected for the study, the prevalence rates measured for Quebec from the MED-ECHO data tend to be lower than the prevalence rates for Canada, whereas the rates estimated by CCASS are higher for Quebec than for Canada. The MED-ECHO data cover practically all Quebec births, compared with only 15% coverage by CCASS, and therefore provide a more accurate picture of congenital anomalies in Quebec.

Key words: *congenital anomalies; disparities; estimates; evolution; prevalence; Quebec*

Background

In its 1992 health and welfare policy, Quebec set itself the goal of reducing the incidence of congenital anomalies. In Quebec, congenital anomalies are the second leading cause of perinatal death and the sixth leading cause, in terms of years of potential life lost, of premature death.[1] Approximately 40% of all babies who die during the first year of life and over 30% of children admitted to a hospital pediatric department have a congenital defect.[1] Furthermore, it has been shown that children born with congenital anomalies are much more likely than others to suffer adverse long-term consequences to their health, quality of life and survival, such as prolonged periods in hospital; multiple surgeries; disrupted physical, intellectual or motor development; and respiratory, visual, auditory or language disorders.[1–3]

Since there is no registration or surveillance system for congenital anomalies in Quebec, there is very little accurate, recent information on the overall incidence of the births of children with congenital defects.[1,4] Thus, it is difficult to know whether Quebec's goal of reducing congenital anomalies is being achieved. In Canada, the only source of information on the birth prevalence of congenital anomalies is the Canadian Congenital Anomalies Surveillance System (CCASS), which for several years has been administered through the Laboratory Centre for Disease Control (LCDC), Health Canada.[5] However, the data are not fully representative of Quebec.

CCASS uses provincial data on cases of congenital defects obtained exclusively from hospital admission/separation records of stillborns, newborns and infants during the first year of life.[6] CCASS does not include cases associated with medical termination of pregnancy for congenital defects, or with miscarriages and abortions, and this limits the coverage of the prevalence of congenital anomalies.

Since there may be several hospitalizations per individual, CCASS uses a melding process to combine information compiled on a single patient during different hospital stays. This process matches variables such as sex, date of birth, residential postal code and health insurance number.

The portion of Quebec hospitalization records compiled by MED-ECHO (the Quebec hospitalization

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database) and sent to Health Canada does not contain all the information needed to identify individuals and meld cases.[5] Therefore, LCDC incorporates into CCASS the Quebec hospitalization data from the Hospital Medical Records Institute (HMRI), an organization that for several years has been administered by the Canadian Institute for Health Information. These data have the advantage of containing the information needed for melding, but the major disadvantage of covering only a small proportion of hospital births in Quebec. From 1989 to 1991, only 15% of Quebec births were captured by the HMRI database,[5] whereas from 1989 to 1995, 99% of live births were registered by MED-ECHO. The CCASS data for Quebec are therefore incomplete and cannot be used to estimate the number of congenital anomalies or accurately measure prevalence.

The goal of this study was to estimate the prevalence of congenital anomalies in Quebec using MED-ECHO data, which are more complete than the HMRI data used by CCASS. We had access to several variables that are not included in the version of MED-ECHO data sent to Health Canada. This enabled us to use identifiers comparable to the ones available from the HMRI database while covering almost all births in Quebec. By combining these data with those from the records of stillbirths, we therefore expect to obtain more accurate results and statistically more robust rates, because they are based on a larger number of events. A deterministic melding method was selected, which is different from, but comparable to, the probabilistic one used in CCASS.

Methods

Data

To estimate the prevalence of congenital anomalies in Quebec as accurately as possible, we used the congenital defects cases from the MED-ECHO hospitalization database and from stillbirth records, which MED-ECHO does not cover. MED-ECHO is the Quebec database on short-term hospitalizations and day surgeries performed in Quebec. Each record contains identifying, demographic information along with the primary diagnosis on admission and 15 possible secondary diagnoses.[4,7] As in the case of CCASS, it was not possible to include cases associated with medical terminations of pregnancy for congenital defects, or with miscarriages and abortions.

The data relating to an individual can be melded using the probabilistic or the deterministic method, depending on the quantity and quality of the information available for correctly identifying individuals.[8] When little information is available, as is the case for CCASS, a probabilistic approach is recommended (based, as its name suggests, on probabilities). To build its database, CCASS uses a variation of this method that involves ad hoc weighting based on a system of weighting factors.[9]

When a large amount of high-quality data is available, a deterministic approach that makes links according to criteria established by the researchers is often preferable. The deterministic method has the advantage of being easier to apply while producing better results than the probabilistic approach.[10] For these reasons, we chose the deterministic approach for this study.

The variables that CCASS selects from MED-ECHO to meld hospitalizations are sex, date of birth, six-digit postal code, health insurance number and the codes from the Ninth Revision of the International Classification of Diseases (ICD-9) for the main diagnosis and the 15 secondary diagnoses. To maximize melds, the following variables were added to these identifiers: admission date, discharge date, medical record number, hospital code, municipality code, regional county municipality code (MRC), local community services centre code (CLSC), type of death, type of care, civil status, origin code and destination code.

Using a deterministic melding procedure, we estimated the number of infants who were hospitalized for congenital anomalies at least once during their first year of life by regrouping the different hospitalization records for each child under the age of one. This was done for the fiscal years from 1988/89 to 1996/97.

The first step consisted of matching hospitalizations by file number, because only one file number can be assigned to an individual in the same hospital no matter how many visits are made. In the second step, hospitalizations with identical health insurance numbers were matched, as these represent another identifier unique to every individual. However, health insurance numbers are frequently available only several months after the child's birth and therefore cannot be used to link visits occurring in the first few months of life. Finally, in the later stages, the following four remaining matches were made based on the place of residence of the hospitalized individuals.

- Identical postal code (six digits), date of birth and sex
- Identical municipality code, CLSC code, date of birth and sex
- Identical postal code (three digits), CLSC code, date of birth and sex
- Identical postal code (three digits), municipality code, date of birth and sex

For the last four melding procedures to be acceptable, each match had to meet the following conditions: the civil status for a second visit could not be "newborn," the discharge from a first visit could not be due to death, the admission date for a second visit could not precede by more than one day the discharge date of the preceding visit and, if the admissions were to the same hospital, the file numbers could not be different.

TABLE 1

Melding procedures for 79,409 hospitalizations for congenital anomalies and other ICD-9 codes selected by CCASS, 1989 1995[a]

Procedure	Hospitalizations eliminated	Number of hospitalizations after each step
MELD I From the file number and hospital	8,228 duplicates eliminated	71,181
MELD II From the health insurance number	470 duplicates eliminated	70,711
MELD III From the postal code (6 digits), date of birth and sex	4,448 duplicates eliminated	66,263
MELD IV From the CLSC, municipality, date of birth and sex	1,744 duplicates eliminated	64,519
MELD V From the postal code (3 digits), the CLSC, date of birth and sex	343 duplicates eliminated	64,176
MELD VI From the postal code (3 digits), municipality, date of birth and sex	45 duplicates eliminated	64,131
FINAL STEP Deletion of information unrelated to congenital anomalies and correction of contradictory diagnoses	4,975 hospitalizations with no diagnosis of congenital anomalies	**59,156** (hospitalizations for congenital anomalies)

TABLE 2

Codes from the Ninth Revision of the International Classification of Diseases (ICD-9) for selected congenital anomalies

Congenital anomaly	ICD-9 code
Anencephalus and similar anomalies	740.0 740.2
Spina bifida	741.0 741.9
Encephalocele	742.0
Congenital hydrocephalus	742.3
Transposition of great vessels	745.1
Hypoplastic left heart syndrome	746.7
Cleft palate	749.0
Cleft palate with cleft lip	749.2
Tracheo-esophageal fistula, esophageal atresia and stenosis	750.3
Atresia and stenosis of large intestine, rectum and anal canal	751.2
Renal agenesis and dysgenesis	753.0
Reduction of limb	755.2 755.4
Anomalies of abdominal wall	756.7
Down s syndrome	758.0

For matches based on the file number and the health insurance number where the date of birth varied between the two visits, we assumed that the date on the first visit was the most accurate. When the sex varied from one visit to another, we used the sex from the most recent visit.

The final operation needed to create the congenital abnormalities database for Quebec was to remove certain cases of contradictory diagnoses using information previously provided by CCASS. Some cases initially identified as congenital anomalies were also associated with particular diagnoses that cancelled the initial diagnosis. Finding one of these diagnoses in addition to a diagnosis of congenital anomalies for the same hospitalization implied there was a contradiction among diagnoses and that this hospitalization, according to CCASS, should not be included among the congenital anomalies.

Table 1 summarizes the procedures carried out on all hospitalizations for congenital anomalies in the MED-ECHO database involving newborns and infants under the age of one.

The data on stillbirths were taken from the stillbirths database for the calendar years 1989–1996. No melding is needed for stillbirths because the cases are unique.

Prevalence and Comparisons

Once we had finished melding the Quebec data on congenital anomalies, we estimated the prevalence of particular congenital anomalies and compared our results with the CCASS results for Canada and Quebec. We also used our Quebec data to examine changes over time and, for certain congenital anomalies, the disparities among health and social services regions.

Like the LCDC researchers, we selected 14 major, relatively common and fairly easily diagnosed congenital anomalies in order to compare our data with the CCASS data[5] (Table 2).

The Quebec rates were calculated for the period 1989–1991 for each of the anomalies and compared with the CCASS rates for the same period.[5] We also

compared the rates for the 1989–1991 period with those for 1993–1995. Finally, for the 10 most common anomalies among the 14 selected, we examined regional disparities during 1989–1995.

Results

During 1989–1991, the CCASS data showed that Quebec recorded prevalences significantly higher than the Canadian average for 9 out of 14 anomalies (Table 3). However, the results were obtained from data covering only 15% of births throughout Quebec and therefore were not necessarily representative of the Quebec situation. In the 1995 Status Report on CCASS, the authors explained this data limitation: "Since hospitals report to HMRI on an individual basis, hospitals that choose to participate may be more specialized and receive more readmissions of infants with congenital anomalies. This will result in higher provincial rates being reported."[5]

The prevalence rates estimated from the MED-ECHO data, which cover almost all births in Quebec, present another picture entirely. Quebec does not have a significantly higher prevalence than the Canadian average for any anomaly; on the contrary, Quebec's rates are significantly lower than Canada's for five anomalies.

The comparison of MED-ECHO data over time shows little variation (Table 4). Between 1989–1991 and 1993–1995, only the rate of *anomalies of the abdominal wall* increased significantly, and only the *spina bifida* rate declined.

The analysis of regional data for 1989–1995 (Table 5) presents some limitations, given the strong variability of the data as represented by the coefficient of variation. In six cases, the rates are significantly above the Quebec average: *spina bifida* in Saguenay–Lac-Saint-Jean and the Terres-Cries-de-la-Baie-James region; *congenital hydrocephalus* in the Côte-Nord region; *congenital atresia and stenosis of the large intestine, rectum and anal canal* in Bas-Saint-Laurent; *anomalies of the abdominal wall* in Estrie; and *Down's syndrome* in Montréal-Centre. In nine cases, the prevalence of a particular congenital anomaly is significantly lower than in Quebec as a whole.

Discussion

The CCASS data for Quebec are taken from the records of the HMRI, which covers only a small proportion of Quebec births and therefore cannot be used to accurately estimate the prevalence of congenital anomalies in Quebec.[5]

TABLE 3

Prevalence rates (per 10,000 total births) of particular congenital anomalies (in infants <1 year old) by data source, 1989 1991, Quebec and Canada

		Data source		
ICD-9 code	Congenital anomaly	MED-ECHO and stillbirths database: Quebec	CCASS:[5] Quebec	CCASS:[5] Canada
740.0 740.2	Anencephalus and similar anomalies	* 1.1 (-)	** 1.4	2.4
741.0 741.9	Spina bifida	6.8	9.9	7.8
742.0	Encephalocele	* 1.0 (-)	** 1.6	1.5
742.3	Congenital hydrocephalus	6.8	14.6 (+)	7.7
745.1	Transposition of great vessels	4.9	15.3 (+)	4.8
746.7	Hypoplastic left heart syndrome	2.6 (-)	* 8.0 (+)	3.4
749.0	Cleft palate	6.9	11.8 (+)	7.3
749.2	Cleft palate with cleft lip	4.9 (-)	* 7.8	8.2
750.3	Tracheo-esophageal fistula, esophageal atresia and stenosis	3.4	* 8.5 (+)	3.8
751.2	Atresia and stenosis of large intestine, rectum and anal canal	5.4	13.4 (+)	5.8
753.0	Renal agenesis and dysgenesis	5.2	* 7.5 (+)	5.0
755.2 755.4	Reduction of limb	5.3	* 5.2	4.6
756.7	Anomalies of abdominal wall	4.5	* 7.3 (+)	4.7
758.0	Down s syndrome	12.4 (-)	24.9 (+)	14.3

* Coefficient of variation greater than 16.5% and less than or equal to 33.3%. The value should be interpreted with caution.
** Coefficient of variation greater than 33.3%. The value is shown as an indication only.
(+)/ (-) Rate significantly higher or lower than the Canadian rate ($p \leq 0.05$)

TABLE 4

Number of cases and prevalence rates (per 10,000 total births) of particular congenital anomalies (in infants <1 year old), 1989 1991 and 1993 1995, Quebec

ICD-9 code	Congenital anomaly	Number of cases: 1989 1991	Number of cases: 1993 1995	Rates: 1989 1991	Rates: 1993 1995	Variation from 1989 1991 to 1993 1995
740.0 740.2	Anencephalus and similar anomalies	40	23	* 1.1	* 0.9	
741.0 741.9	Spina bifida	194	147	6.8	5.5	▼
742.0	Encephalocele	28	32	* 1.0	* 1.2	
742.3	Congenital hydrocephalus	193	183	6.8	6.9	
745.1	Transpositon of great vessels	140	139	4.9	5.2	
746.7	Hypoplastic left heart syndrome	75	73	2.6	2.7	
749.0	Cleft palate	195	195	6.9	7.3	
749.2	Cleft palate with cleft lip	140	148	4.9	5.6	
750.3	Tracheo-esophageal fistula, esophageal atresia and stenosis	97	91	3.4	3.4	
751.2	Atresia and stenosis of large intestine, rectum and anal canal	153	137	5.4	5.1	
753.0	Renal agenesis and dysgenesis	148	164	5.2	6.2	
755.2 755.4	Reduction of limb	150	124	5.3	4.7	
756.7	Anomalies of abdominal wall	127	171	4.5	6.4	▲
758.0	Down s syndrome	353	332	12.4	12.5	

* Coefficient of variation greater than 16.5% and less than or equal to 33.3%. The value should be interpreted with caution.

(▼) / (▲) Significant reduction or increase between the two periods ($p \leq 0.05$)

This study shows that using hospitalization data from MED-ECHO could be a worthwhile solution for CCASS. The MED-ECHO database covers virtually all Quebec births and contains the necessary information for melding the various hospitalizations for one individual.

The study makes it possible for the first time to accurately estimate the prevalence of particular congenital anomalies in Quebec and follow them over time. It also enables regional comparisons to be made and Quebec rates to be compared with overall rates in Canada.

The results show that, for the selected anomalies, the prevalence rates tend to be lower in Quebec than in Canada and there is little variation over time. Because of the strong variability of the data measured by region, regional comparisons do not yield clear trends.

To obtain even more accurate data on congenital anomalies, it will be necessary to include the information on medical termination of pregnancy for congenital anomalies, and on miscarriages and abortions, as has been done in international systems.[4,11,12] Such additions are especially worthwhile given the improvement and greater availability of early detection methods (ultrasonography, cord puncture, amniocentesis, trophoblast biopsy, etc.).[13,14]

Although the deterministic approach is superior to the probabilistic approach for linking the various events relating to one individual, using a single identifier to follow one person among all the data sources is by far the most accurate method of measuring the actual number of congenital anomalies.[8,10]

The role played by administrative practices in relation to hospitalization should be measured in geographic and temporal comparisons of the prevalence of congenital anomalies. It is possible that higher levels of congenital anomalies simply reflect a greater propensity to indicate a congenital anomaly code.

Finally, it remains to be seen which of the anomalies could be selected as sentinel causes.

TABLE 5

Prevalence rates (per 10,000 total births) of particular congenital anomalies by region, Quebec, 1989 1995

Region	ICD-9 code									
	741.0 741.9	742.3	745.1	749.0	749.2	751.2	753.0	755.2 755.4	756.7	758.0
	Spina bifida	Congenital hydro-cephalus	Transpo-sition of great vessels	Cleft palate	Cleft palate with cleft lip	Atresia and stenosis of large intestine, rectum and anal canal	Renal agenesis and dys-genesis	Reduction of limb	Anomalies of abdominal wall	Down s syndrome
01	* 5.7	* * 3.1	* * 3.8	* 9.4	* * 1.9	* 15.1 (+)	* 5.7	* 7.5	* * 5.0	* 11.9
02	* 10.6 (+)	* 7.1	* 5.5	* 11.0	* 7.5	* 5.5	* 9.0	* 7.1	* 5.9	* 10.6
03	* 5.5	* 9.1	* 4.9	9.3	* 5.5	* 5.9	7.7	* 3.9	* 3.9	12.0
04	* 6.6	* 8.1	* 3.3	* 7.9	* 6.3	* 3.8	* 5.1	* 2.8 (-)	* 5.3	* 8.6 (-)
05	* 4.9	* 7.8	* 5.3	* 7.4	* 4.9	* 6.6	* * 2.9	* 4.1	* 9.4 (+)	* 8.2 (-)
06	4.1 (-)	6.8	5.0	5.2 (-)	4.4	5.0	5.5	4.5	4.9	15.9 (+)
07	* 7.4	* * 1.6	* 4.1	* 4.1 (-)	* 6.2	* * 2.5	* * 2.9	* 3.7	* * 2.1	* 9.4
08	* 9.6	* * 5.1	* * 3.8	* 8.9	* 6.4	* 5.7	* 5.7	* * 3.8	* 6.4	* 7.7 (-)
09	* 10.1	* 14.2 (+)	* * 1.0	* 10.1	* * 8.1	* * 3.0	* * 7.1	* * 6.1	* * 8.1	* 13.2
10	* * 4.4	* * 4.4	* * 0.0	* * 4.4	* * 13.3	* * 4.4	* * 0.0	* * 4.4	* * 4.4	* * 4.4
11	* 12.5	* * 7.5	* * 7.5	* * 7.5	* * 1.2	* * 3.7	* * 3.7	* * 5.0	* * 3.7	* 22.4
12	* 8.1	* 6.9	* 5.7	* 5.4	* 6.0	* 6.6	* 7.5	* 4.8	* 6.6	15.6
13	* 5.4	* 3.2 (-)	* 3.5	* 7.1	* 5.1	* 4.2	* 5.8	* 5.1	* * 1.9	13.1
14	* 2.5 (-)	* 5.6	* 5.6	* 6.4	* 4.2	* 5.8	* 6.9	* 7.5	* 6.7	11.7
15	* 5.7	* 5.5	* 3.2	* 4.7	* 4.5	* 5.5	* 5.7	* 3.5	* 4.0	10.5
16	5.1	6.3	5.0	7.1	5.5	4.1	5.6	5.0	6.6	11.0
17	* * 0.0	* * 16.7	* * 0.0	* * 5.6	* * 44.5	* * 27.8	* * 0.0	* * 5.6	* * 22.2	* * 22.2
18	* 44.3 (+)	* * 9.9	* * 4.9	* * 19.7	* * 4.9	* * 0.0	* * 4.9	* * 4.9	* * 9.9	* * 19.7

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Monograph Series on Aging-related Diseases: XII. Parkinson s Disease Recent Developments and New Directions

Natalie Kontakos and Julie Stokes

Abstract

Parkinson's disease, a chronic progressive disorder of the central nervous system characterized by tremor, rigidity and bradykinesia, usually affects those over the age of 50. Recent developments in research on Parkinson's disease include investigation of the possible role of diet and a growing interest in genetics and inherited factors. The identification of biological markers and other environmental risk factors will play a significant role in future research of the disease as they will be important in the development of prevention strategies.

***Key words**: Canada; diagnosis; morbidity; mortality; risk factors; treatment*

Introduction

Parkinson's disease (PD) is a neurodegenerative disorder that primarily affects voluntary, co-ordinated movement. It is a disease of late middle age, usually affecting those over the age of 50. Although the discovery of PD is often attributed to James Parkinson and his 1817 monograph entitled *The Shaking Palsy*,[1] descriptions of parkinsonian syndromes date back to the ancient Ayurvedic literature of India, from 4500 to1000 BC.[2] The first breakthrough in PD research was in the 1960s, when the dopamine hypothesis and levodopa therapy were introduced.[1] There has since been much progress in disease definition and diagnosis, surveillance, knowledge of etiology and disease progression, and treatment. Although the cause of PD is not yet known and a cure has not been found, the past few years of research have lead to a greater understanding of the disease. As well as providing an overview of PD, this report focuses on the recent advances and the future directions of PD research.

Background and Natural History

PD is a chronic and progressive disorder of the central nervous system. It is the most common form of the parkinsonian syndromes, a group of motor system disorders that share the primary symptoms of tremor, rigidity and bradykinesia. Most studies indicate that there must be two of these three features for a diagnosis of parkinsonism.[3–5]

Parkinsonian syndromes occur when the neurons that lie in the brain stem's substantia nigra ("black substance") are destroyed.[4] The neurotransmitter dopamine is normally produced in the neurons of the substantia nigra. These neurons connect with other neurons in the corpus striatum, which in turn send messages to the motor-controlling areas of the cortex. Dopamine is depleted as the neurons of the substantia nigra diminish in number; therefore, the number of signals to the corpus striatum and from there to the cortex are decreased. The normal functioning of the motor system is thus disrupted (Figure 1).

Depletion of dopamine in the brain can come about in a number of ways. Parkinsonian syndromes may be induced by drugs, viral infections, hereditary diseases or metabolic causes. Parkinsonism and syndromes such as progressive supranuclear palsy and multiple system atrophy may present as relatively pure parkinsonism in the early stages of disease, with nonparkinsonian signs becoming more prominent with time. Other degenerative diseases of the central nervous system may either occur concurrently with PD or may exhibit some parkinsonian

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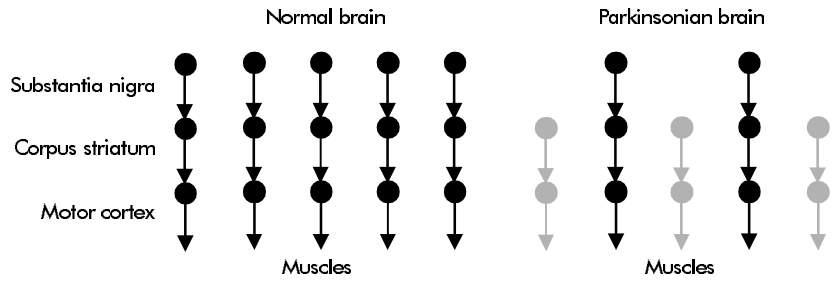
symptoms. Stroke, tumours, trauma and other nondegenerative conditions may influence the level of dopamine in the substantia nigra and/or corpus striatum and thus include parkinsonian features.

PD is different from most other parkinsonisms in that the cause of the destruction of the substantia nigra leading to dopamine reduction is not known.[4] Many ideas, such as the "oxidative stress model",[6,7] have been brought forward to explain how PD begins, but none has been fully accepted.

FIGURE 1

Difference between a normal brain and a parkinsonian brain



The pathological classification of PD includes the degeneration of specific groups of nerve cells, including the substantia nigra.[4] Poor circulation or arteriosclerosis cannot explain the location of the affected cells. PD can also be diagnosed after death on the basis of the Lewy body, a round inclusion found within degenerating neurons. Lewy bodies are highly characteristic of the disease.

Burden of Disease

Morbidity

According to a recent World Health Report, PD affects 3,765,000 individuals worldwide, and the condition is diagnosed in 305,000 people per year.[8] In 1996, there were 2,635,000 people with PD who were chronically disabled and 58,000 deaths. Although PD affects individuals worldwide in all ethnic groups and from all socio-economic backgrounds, statistics reflecting the disease's morbidity and mortality vary widely from place to place. In fact, a recent review of the worldwide occurrence of PD[9] revealed that there was a 13-fold difference between the highest (Uruguay) and the lowest (China) prevalence estimates in door-to-door studies, and a 3-fold difference between the highest (Iceland) and the lowest (Libya) locations in studies relying on data from sources such as hospitals, physicians and health insurance records. Incidence estimates exhibited a 10-fold difference between the highest (United States) and lowest (China) areas.

These ranges in prevalence and incidence may suggest environmental or genetic clues to the disease's etiology. They may also be due to other factors, such as differences in diagnostic procedures or population groups. Since this review standardized the rates for all studies to a single population, the variations cannot be attributed to populations of different age structures. Case ascertainment may be used to explain the difference in estimates between door-to-door studies and other studies that do not actively seek out individuals with PD.

The literature in the past has been quite consistent in reporting higher PD rates in primarily Caucasian populations as compared with Asian or black populations. More recent studies indicate that the variation in the prevalence of PD among different ethnic groups is not as large as it was once thought to be, but prevalence still varies from study to study.[10–17] A greater consistency in study methodologies probably explains this shift.

Recent incidence studies conducted in the United States and Europe all reveal PD incidence rates between 8 and 13 per 100,000.[15,18–20] All studies that included information specific for each sex reported higher incidence rates among males than females. The high male incidence rate in a study completed in Manhattan, United States,[15] is largely attributed to the incidence rate among black males; in comparison to the rate among white males it was consistently higher in every age group, with a 4-fold difference in those over the age of 80. The duration of disease is probably shorter in black males, since the same study observed lower prevalence rates among black as compared with white males.

A Swedish study that used records from a health maintenance organization (HMO)[20] observed a higher crude incidence rate among whites than among blacks, Hispanics or Asians; Asians had the lowest rate. A cohort of male Hawaiian residents, of primarily Japanese or Okinawan ancestry,[18] had an incidence rate in between that of the Manhattan study and the HMO study. The authors concluded that environmental factors were more important than genetic factors in this group of men, since Asian incidence rates reported previously were lower.

All studies showed incidence rates that increased linearly with age up until the age of 75. At this point, the incidence rate in most groups either plateaued or continued to increase linearly. The incidence rate in the Hawaiian cohort, however, decreased, and the rate among males in Manhattan increased even more steeply.

Morbidity in Canada

There are few data describing the prevalence and incidence of PD in Canada. Since most patients do not require hospital care on an in-patient basis, hospital

separation rates underestimate the prevalence of PD. These rates are also problematic in that they are not based on the number of individuals but, rather, on the number of discharges. An individual can therefore be counted more than once. Despite the drawbacks, hospital separation rates can be useful in detecting general differences and trends. The overall hospital separation rate for PD (coded as paralysis agitans ICD-9 332.0) for the 1991–1995 period was 15.4 per 100,000 among men and 8.9 per 100,000 among women (Table 1). There was considerable variation from province to province, ranging from 8.0 per 100,000 in Newfoundland to 19.3 per 100,000 in Saskatchewan. This variation may be partly explained by different disease coding or hospital admission practices.

During 1991**S**1995, hospital separation rates increased with age and peaked among individuals aged 80–84. Males had higher hospitalization rates than females in every age category (Table 2), and the overall hospital separation rates were higher among males in every province.

From 1976**S**1980 to 1991**S**1995, there was a 25% reduction in hospital separations for PD over all age groups. Among females the rates have been decreasing since 1976**S**1980, but the rates among males peaked during 1986**S**1990. The decline in hospital separation rates can be attributed to the fall in the younger age groups, especially in females. There has actually been an increase in hospital separation rates in the older age groups.

Excluding routine data such as hospital separation rates, there have been very few documented attempts to estimate the prevalence of PD in Canada. A 1988 British Columbia rural community study[21] revealed a crude prevalence rate of 69 per 100,000, which is considered to be low compared with that of other communities. No age-specific rates were reported, however, so comparisons could not be made. Another study involved a cohort of individuals registered with the Alberta Health Care Insurance Plan who were followed for a five-year period.[22] PD patients were identified through physician billing information in which a diagnostic code for PD was included. The crude prevalence rate was found to be 244.4 per 100,000. The rate was higher among males than females, and 81% of all cases were 60 years of age or older.

A study conducted in Saskatchewan found that 3% of individuals over the age of 65 had PD.[23] This estimate is rather unstable, since it was based on only two positive cases among 70 subjects. A similar study found a 6% rate of PD in a chronic care facility.[24] Studies in other countries have revealed that the higher prevalence of PD among those living in chronic care facilities is largely due to a higher prevalence in the "young-old" age groups.[25,26]

Mortality

International mortality rates increase with age and are consistently higher among males. Recently published mortality rates show that rates are similar in European countries[27–29] and lower in Japan.[30] There has been a steady increase in mortality rates among older populations (>75 years) and declining rates among younger populations (<65 years).[31]

TABLE 1

Average annual hospital separation rates[a] (per 100,000) for Parkinson s disease by sex, province and period, Canada, 1976 1995

	1976 1980		1981 1985		1986 1990		1991 1995	
Province	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Nfld	17.2	10.5	14.4	10.7	14.2	10.3	9.3	7.2
PEI	13.2	18.3	15.6	21.2	11.2	15.0	12.2	7.3
NS	14.2	9.5	16.3	11.0	17.1	10.7	12.8	6.7
NB	20.1	13.2	18.4	13.3	17.1	10.5	15.2	9.1
Que	7.9	6.7	9.4	6.6	12.7	7.5	13.6	8.2
Ont	19.2	13.7	19.2	11.6	19.4	10.4	14.1	7.8
Man	20.0	14.0	19.1	14.0	21.9	12.6	19.9	11.4
Sask	31.1	24.9	27.0	23.1	32.4	20.6	23.5	16.4
Alta	27.4	22.1	30.4	21.5	22.7	14.2	12.0	8.0
BC	23.8	16.7	26.3	15.8	26.5	16.4	21.2	11.9
CANADA	18.3	13.2	19.0	12.2	19.6	11.3	15.4	8.9

[a] Standardized to the 1991 census population
Source: Laboratory Centre for Disease Control, based on data from Statistics Canada

TABLE 2

Average annual hospital separation rates[a] (per 100,000) for Parkinson s disease by sex, age and period, Canada, 1976 1995

	1976 1980		1981 1985		1986 1990		1991 1995	
Age (years)	Males	Females	Males	Females	Males	Females	Males	Females
ALL AGES	18.3	13.2	19.0	12.2	19.6	11.3	15.4	8.9
45 64	14.5	12.2	13.4	9.4	10.7	7.4	7.9	6.2
65 69	66.3	61.8	62.6	51.6	62.7	39.3	43.2	32.2
70 74	133.9	104.1	125.0	92.3	126.0	85.2	95.1	58.2
75 79	176.7	124.6	208.7	131.6	206.0	129.8	169.0	100.9
80 84	210.3	116.8	250.8	131.4	293.9	137.5	232.4	117.2
85+	188.1	78.6	200.2	87.9	258.8	96.8	224.4	84.5

Mortality in Canada

Although most PD patients do not die as a result of the disease, mortality data can be examined to identify differences in the disease's distribution according to geographic area, sex, age and time. Mortality rates may also draw attention to differences in treatment and management. The overall mortality rate for PD during the 1992–1996 period was 3.4 per 100,000 (Table 3). Two provinces had mortality rates that were significantly different from the national rate: Ontario showed a significantly higher rate (3.7 per 100,000) and Alberta a significantly lower rate (2.6 per 100,000) for all ages. As with other rates, these differences may be real or they may be due to other factors, such as provincial differences in coding death certificates.

During 1992**S**1996, mortality rates increased with age and did not reach a peak like the hospital separation rates (Table 4). Males had higher mortality rates than females in all age groups, and, as with hospital separation rates, overall mortality rates were higher among males in all provinces.

Over time, standardized mortality rates have increased among both males and females. The increase among males from 1977**S**1981 to 1992**S**1996 was greater (93%) than the increase among females (79%). As with hospital separation rates, the increase in PD mortality is largely attributed to a greater increase of PD in older age groups than in younger age groups. The mortality rates in younger age groups, however, have not decreased to the extent that hospital separation rates have.

TABLE 3

Average annual mortality rates[a] (per 100,000) for Parkinson s disease by sex, province and period, Canada, 1977 1996

	1977 1981		1982 1986		1987 1991		1992 1996	
Province	Males	Females	Males	Females	Males	Females	Males	Females
Nfld	1.8	0.9	2.1	2.3	5.6	1.9	5.4	2.7
PEI	1.5	0.8	3.0	1.4	4.7	2.6	2.8	2.0
NS	2.3	0.7	2.5	1.4	4.1	1.8	4.4	2.1
NB	2.2	1.4	2.5	1.8	3.5	1.7	4.4	2.1
Que	2.1	1.1	2.6	1.5	4.0	2.1	4.9	2.5
Ont	2.6	1.4	3.8	1.7	4.7	2.2	5.7	2.6
Man	2.5	1.2	3.4	1.4	3.8	2.2	5.1	2.0
Sask	2.6	1.1	2.6	1.5	2.8	1.9	4.9	2.2
Alta	2.2	1.7	3.0	1.7	3.2	1.7	3.8	1.8
BC	4.3	2.0	3.0	1.7	4.3	1.9	4.7	2.5
CANADA	2.6	1.4	3.1	1.6	4.2	2.0	5.1	2.4

[a] Standardized to the 1991 census population
Source: Laboratory Centre for Disease Control, based on data from Statistics Canada

TABLE 4

Average annual mortality rates[a] (per 100,000) for Parkinson s disease by sex, age and period, Canada, 1977 1996

	1977 1981		1982 1986		1987 1991		1992 1996	
Age (years)	Males	Females	Males	Females	Males	Females	Males	Females
ALL AGES	2.6	1.4	3.1	1.6	4.2	2.0	5.1	2.4
45 64	0.7	0.4	0.6	0.3	0.6	0.3	0.6	0.4
65 69	5.8	3.1	5.8	3.2	6.0	2.6	6.2	2.8
70 74	16.1	6.7	16.0	7.6	17.4	7.9	19.1	9.8
75 79	28.7	14.4	35.2	20.4	42.8	21.0	56.2	23.8
80 84	43.5	24.1	60.0	31.8	81.1	40.2	92.4	47.1
85+	53.6	30.2	72.0	34.6	123.4	62.2	158.2	77.4

[a] Standardized to the 1991 census population
Source: Laboratory Centre for Disease Control, based on data from Statistics Canada

Risk Factors

Environmental Factors

The search for an environmental agent causing PD has been quite intensive. It heightened in the mid to late 1980s when MPTP (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine), a rare contaminant of heroin, was found to elicit clinical and pathological features virtually identical to those of PD.[32,33] It was thought that an environmental toxin with chemical and physical properties similar to MPTP could lead to PD. Although no such toxin has been found to be causally associated with PD, studies have offered substantial evidence to eliminate certain hypotheses and to explore other hypotheses further.

Rural living

Although studies in the past had pointed to an association between rural living and PD, the most recent studies are quite inconsistent in their results. Not only are the results inconsistent, but so are the periods of exposure under investigation.

Two studies found elevated and significant odds ratios (ORs) for rural living near the time of diagnosis,[34,35] whereas another study found PD mortality to be positively correlated with population density.[36] A Chinese study that found an OR of less than 1 for living in small cities did not specify the exposure period of interest.[37] One study from the US found an elevated and significant OR for a history of rural residence only for blacks and not for other ethnic groups.[38] The average population density of places of residence from birth to the time of diagnosis did not differ between cases and controls in one study,[39] and another showed no association between the place of residence for the first 15 years of life and the risk of PD.[40] Since PD is believed to have a long latent and asymptomatic period,[41] the probable relevant exposure period would be earlier rather than later in life.

Because there are many specific exposures associated with rural areas, recent studies have attempted to measure these exposures in order to explain the association between PD and areas of low population density.

Three recent studies[36,42,43] have found an association between PD and agricultural work. One of them[43] looked solely at death certificates, and another[36] found a positive correlation between the number of PD deaths and farming density. In the third study,[42] the OR for grain and crop farming was significant in univariate analysis but not in multivariate analysis. A German study reported an elevated and significant relative risk associated with mushroom harvesting during childhood and adolescence;[44] however, no association was found with previous farm activity or employment in agricultural work, living on a farm or having a farm near to the home, having contact with farm animals or involvement in slaughter. Other recent studies[34,38] have found no association between PD risk and farming.

Pesticide exposure

The similarity between the structures of the MPTP metabolite MPP+ and the herbicide paraquat encouraged the investigation of a possible relation between pesticide exposure and PD (Table 5).[34,35,39,45–48] A study in Taiwan indicates that the OR for PD was 2.0 among those subjects who had used both paraquat and other herbicides/pesticides when compared with those exposed to pesticides and herbicides other than paraquat.[48] Recent studies have consistently shown an increased risk of PD with pesticide exposure, and in some this has achieved statistical significance.

Well water

Well water has also been implicated in PD. Of all the recent studies, only those conducted in Italy[49] and Spain[50] have found a positive association between drinking well water and the risk of PD. A study that examined the relation between PD mortality and the proportion of well water users in Michigan showed a negative correlation between the exposure and the disease,[36] and a Chinese study also reported a decreased risk of PD associated with drinking well water.[37] Four studies found no association,[38–40,48] and no contaminant thought to contribute to the cause of PD has been found in well water.

Metal exposure

Some metals, such as manganese and mercury, have been shown to induce parkinsonian signs and symptoms in individuals who were heavily and acutely exposed.[51] Recent epidemiologic studies have looked at mainly occupational metal exposure as a risk factor for PD. No significant ORs were found in studies conducted in British Columbia[47] or Alberta.[45] A German study found only one significant OR for occupational exposure to lead.[39] This, however, was barely significant and only when compared with one of two control groups. Another OR that was just significant and involved only one control group was found for exposure to mercury through amalgam fillings. An ecological study reported that counties in Michigan with iron and copper industries had higher PD mortality rates.[36] In another study, elevated ORs for 20 years of occupational exposure to copper, manganese and various combinations of metals suggested that metal exposure may play a role in PD etiology.[52] However, the finding that serum and urine levels of manganese, chromium and cobalt did not differ between PD patients and controls led the authors of another study to suggest that exposure to these metals is unrelated to PD.[53]

TABLE 5

Recent studies investigating the association between pesticide use and risk of Parkinson s disease (PD)

Study authors	Location	Relation between pesticide use and PD risk
Butterfield et al.[34]	United States	Insecticide exposure: odds ratio (OR) = 5.75 (significant) Past residency in a fumigated household: OR = 5.25 (significant) Herbicide exposure: OR = 3.22 (significant)
Hertzman et al.[47]	Canada	Occupational pesticide use in males: OR = 2.03 (95% CI = 1.00 4.12) versus cardiac disease controls and OR = 2.32 (95% confidence interval [CI] = 1.10 4.88) versus electoral list controls Not significant in women
Hubble et al.[46]	United States	Pesticide use: OR = 3.42 (95% CI = 1.27 7.32)
Liou et al.[48]	Taiwan	Occupational or residential exposure to herbicides/pesticides: OR = 2.89 (95% CI = 2.28 3.66) Paraquat exposure: OR = 3.22 (95% CI = 2.41 4.31)
Morano et al.[35]	Spain	More cases than controls were exposed to pesticides but relative risk estimate was not significant
Seidler et al.[39]	Germany	Herbicide use: significant for 1-dose category versus regional controls (41 80 dose-years: OR = 3.0 [95% CI = 1.5 6.0]) but not versus neighbourhood controls Insecticide use: significant OR in the 2 lower dose categories versus regional controls; OR not significant versus neighbourhood controls Organochlorines: significant OR versus regional controls Alkylated phosphates and carbamates: significant OR versus regional controls

Non-metallic toxins

The relation between PD and numerous other toxins has been investigated. Although one study[54] reported positive associations with plastic resins, epoxy resins, glues, paints and petroleum, it also found a multitude of other exposures not to be significant, leading to a problem with multiple comparisons. Higher mortality rates from PD were found in counties with paper and chemical industries.[36] Other studies have not found a relation with industrial toxins,[35] carbon monoxide,[39,45] cyanide,[45] exhaust fumes[39] or glues, paints and lacquers.[39] More PD patients than control patients have reported that they had wood panelling in their homes;[55] this may implicate wood preservatives in the etiology of PD.

Head injury

Head injury has been implicated in the etiology of PD, possibly through the microglial cells, which are involved in the inflammatory process.[6] Two of four[35,39,45,56] recent studies found significant ORs with head trauma. The OR in one of these was barely significant and existed only in a comparison with one control group;[39] the other reported an OR that remained significant after multivariate analysis.[45] Studies examining head trauma may involve recall bias, and this issue should be addressed in future studies.

Smoking

Epidemiologic studies have consistently shown smoking to be protective for PD. The majority of recent studies seem to support this relation, as they have reported ORs of less than 1 (Table 6).[34,39,40,45,56–59] In addition to this evidence, a prospective study involving the Honolulu Heart Study revealed a significant relative risk of 0.39.[60] Some experimental evidence supports the idea that nicotine may be protective for PD. One study showed that chronic nicotine intake in rats decelerated the age-associated decrease in dopamine receptors and in dopamine re-uptake.[61]

Other case-control studies, however, do not support the claim that smoking is protective for PD. Longitudinal Gompertzian analysis, which considers the three dimensions of genetics, environment and selective early mortality, demonstrates that a neuroprotective influence does not explain the negative association between PD and smoking.[62] The negative association has been explained by the fact that smokers die sooner than non-smokers.

TABLE 6

Recent case-control studies examining the relation between smoking and Parkinson s disease (PD)

Study authors	Location	OR	Comments
Butterfield et al.[34]	United States	0.50* 0.43* 0.37*	At 5 years before diagnosis At 10 years before diagnosis At 15 years before diagnosis
Hellenbrand et al.[59]	Germany	0.5* 0.2*	History of smoking Current smoker
Martyn and Osmond[56]	England	0.50*	History of smoking
Mayeux et al.[57]	United States	1.1 0.20*	History of smoking At the time of interview
Seidler et al.[39]	Germany		PD patients reported fewer pack-years
Semchuk et al.[45]	Canada	0.48* 0.58	Univariate analysis Multivariate analysis
Tzourio et al.[58]	Europe (France, Italy, Spain, Netherlands)	1.1 0.4*	History of smoking <75 years of age and history of smoking
Vieregge et al.[40]	Germany	0.37* 0.42 0.24	History of smoking Smoking for a duration of 2 years Smoking more than 10 cigarettes per day

* $p < 0.05$

Tzourio et al.[58] found no overall protective effect of smoking in relation to PD but, when adjustments were made for age, tobacco was found to be protective in the younger age group while representing an increased risk in the older age group.

Although smoking has been found to be protective for PD, it is an important risk factor for many other major diseases, and the adverse effects of smoking far outweigh any possible benefits.

Diet

Diet has only recently been implicated in the etiology of PD. According to the oxidative stress model, an increase in antioxidants would prevent damage and death to dopaminergic cells by scavenging more free radicals. Therefore, antioxidants present in foods and available in supplements would be protective for PD. Epidemiologic studies that have examined the association between antioxidants and PD have been inconsistent (Table 7);[63–68] no study replicated any finding of a negative or positive association. The two prospective studies[63,65] used dietary history information collected before PD was diagnosed; in one,[63] the period from dietary to disease assessment was only a few years.[63] Since the disease process is thought to start many years before the individual is symptomatic, the dietary information obtained in the latter study may be irrelevant in terms of PD etiology. The other three studies[64,66,67] did not fare any better, in that they were case-control studies whose data focused on the individual's dietary pattern over the previous year.

Three other case-control studies[34,44,68] examined the relation between PD and foods rich in vitamin E. Although there was no difference in intake of foods rich in vitamin E in two of the studies,[44,68] the third reported an elevated and significant OR for nuts and seeds, which are rich in vitamin E.[34] One of these studies[68] found a higher intake of vitamin C in PD patients.

Studies relating antioxidant serum levels with PD status have also been performed. Three studies[69–71] found no difference in vitamin E serum levels between PD patients and healthy controls. One of these studies[70] also found no difference in vitamin A levels but did find higher vitamin C levels in PD patients; the vitamin C levels in controls, however, were low compared with established data in young healthy individuals. It is important to note that these studies included levels measured after the time of diagnosis and may not reflect levels before disease onset.

The relation between other dietary variables and PD etiology has also been recently examined. An ecological study reported significant and positive correlations between age-adjusted mortality rates in 17 different countries and the per capita consumption of total dietary protein and meat.[72] In addition to the limitations inherent

TABLE 7

Studies investigating the association between antioxidant intake and risk of Parkinson s disease (PD)

Study authors	Location	Food source	Odds ratio (and 95% CI)	Conclusions/Comments
Cerhan et al.[63]	United States	Vitamin C (lowest vs highest tertile) Manganese Vitamin A Retinol Beta carotene, vitamin E, zinc and selenium	0.5 (0.2 1.0) 0.4 (0.2 0.9) 2.1 (1.0 4.1) 1.9 (0.9 3.7) No association	Certain antioxidants may be protective agents for PD while others may be risk factors
de Rijk et al.[67]	Netherlands	Vitamin E (/10 mg) Beta carotene (/1 mg) Vitamin C (/100 mg) Flavonoids (/10 mg)	0.5 (0.2 0.9) 0.6 (0.3 1.3) 0.9 (0.4 1.9) 0.9 (0.7 1.2)	Vitamin E may be protective for PD
Gorell et al.[66]	United States	Vitamins A, B, C, E and beta carotene	No association	No association between intake of these vitamins and PD
Logroscino et al.[64]	United States	*From supplements*: Carotenoids Vitamins A, C, E and retinol *From food*: Vitamins	 Marginal linear trend ($p = 0.095$) Not associated with PD No association	No difference in antioxidant intake between PD patients and controls
Morens et al.[65]	United States	Vitamin E (continuous variable)	0.88 (0.63 1.23)	Inconclusive results the possibility that vitamin E may be protective for PD is not ruled out
Scheider et al.[68]	United States	Vitamin E Vitamin C Total carotene	1.15 (0.47 2.80) 2.13 (0.89 5.11) 2.27 (0.83 6.17)	No protective effect for vitamin E Greater PD risk with higher intakes of vitamin C and carotenoids

in ecologic studies, the study not only used mortality rates, which in comparison to other statistics do not accurately indicate the prevalence of PD, but also used figures from 1952 to 1958, which do not reflect the present rates. Two case-control studies[64,66] found an elevated and significant OR with fat intake. One of these[66] also reported elevated and significant ORs for cholesterol, iron and lutein. Since lipids are one of the major sources of free radicals, the increase in fat and cholesterol intake is consistent with the oxidative stress model. The positive association with lutein may be a result of PD, as many patients increase their consumption of lutein to manage the disease's symptoms.

A German study reported that PD may be related to a variety of foods.[73] PD patients consumed more chocolate, desserts, organ and raw meats, and less beer and coffee. The relation between the disease and these food items might be related to the effects of biogenic amines (chocolate), insulin levels (foods rich in refined carbohydrates), infectious agents (organ and raw meats), ethanol (beer) and caffeine (coffee) on the dopaminergic system. Another study has also found a negative association between alcohol consumption and PD.[74]

Infections

The idea that PD may be infectious in origin is largely due to the onset of parkinsonian symptoms in individuals infected with the virus associated with lethargic encephalitis in the 1920s.[75] Numerous studies have failed to find an association between PD and a variety of common viruses and bacteria. Chicken pox, measles, rubella, mumps, the Spanish flu[45] and the *Nocardia* species[76] were all found to be unrelated to PD in recent studies. A study conducted in the United Kingdom reported that PD patients were more likely to recall suffering from croup or diphtheria in childhood.[56] It is important to note however, that these results are not based on antibody serum levels and that the neurotoxin produced by the organism of diphtheria cannot cross the blood**S**brain barrier.

An etiologic hypothesis involving whooping cough was brought forward when a positive relation between PD and whooping cough outbreaks in one-year birth cohorts was found in Iceland.[77] PD patients also had higher antibody responses to coronaviruses than did healthy controls, suggesting an association between these RNA-containing viruses and PD.[78] The observation that there is a higher prevalence of gastrointestinal ulcers in

PD patients has led to the hypothesis that *Helicobacter pylori*, the Gram-negative bacterium responsible for the majority of cases of ulcers, may have a role in PD etiology.[79]

Genetics and Inherited Factors

For many years, epidemiologists focused most of their attention on environmental risk factors. Hereditary influences seemed less likely because twin studies in the past had shown similar concordance rates among monozygotic and dizygotic twins.[55,80,81] More recently, however, there has been a growing interest in genetic factors, largely due to the realization that family history is an important risk factor in the etiology of PD.

Family history

Many epidemiologic studies have investigated the association between the risk of PD and a family history of the disease (Table 8).[34,35,37,39,45,49,82–85] Most, if not all, studies have consistently reported a significantly elevated OR for a family history. Although it is possible that recall and selection biases may explain some of the observed association, the consistency, strength and universality of the results support a role for early life environmental exposures or some underlying genetic predisposition to the disease. Furthermore, a study by Uitti et al.[86] identified previously undiagnosed cases of PD among families who had reported no family history of the disease, suggesting that patients' reports of the absence of familial parkinsonism may be inaccurate. The results of this study also indicate that the weighted prevalence rate of familial parkinsonism is more than five times greater than the reported prevalence rates of PD in the general population.

TABLE 8

Controlled studies investigating the association between family history of Parkinson s disease (PD) and risk of PD

Study authors	Location	OR	Comments
Bonifati et al.[83]	Italy	4.95*	Positive family history
Butterfield et al.[34]	United States	2.97*	Positive family history
De Michele et al.[49]	Italy	14.6*	Positive family history
Marder et al.[85]	United States	2.3*	First-degree relatives
Morano et al.[35]	Spain	3.92*	Positive family history
Payami et al.[82]	United States	3.5*	First-degree relatives
Seidler et al.[39]	Germany	12.6* 5.0*	First- or second-degree relatives vs neighbourhood controls First- or second-degree relatives vs regional controls
Semchuk et al.[45]	Canada	2.36* 3.73* 5.76*	First-degree relatives First- or second-degree relatives First-, second- or third-degree relatives Multivariate model
Vieregge[84]	Germany	7.05*	Positive family history
Wang et al.[37]	China	4.33*	Positive family history

* $p < 0.05$

A number of families with multiple cases of PD have been reported in the literature. Some of the most impressive kindreds include a family with 18 affected individuals within six generations.[87] Not only did autopsy findings include features consistent with PD, but clinical symptoms such as age of onset and responsiveness to levodopa were also in agreement with typical cases. Other families include the Contursi kindred with 60 affected individuals in five generations.[88] A Greek-American kindred whose 16 affected members in three generations showed asymmetric rigidity, resting tremor, bradykinesia and postural instability were also responsive to levodopa.[89] The data from all of these families are consistent with an autosomal dominant mode of inheritance with reduced penetrance. In addition, a comparison between familial and sporadic cases of PD revealed that the clinical parameters and the course of disease were similar.[90]

Genetic markers

Many researchers are attributing gene identification in one family as the biggest breakthrough in PD research since the observations of dopamine deficiency[91] and subsequent successful symptom control with levodopa.[92] An article first reported that genetic markers on chromosome 4q21-q23 were found to be linked to individuals with PD in a large Italian kindred.[93] Then, less than one year later, a second article described the exact gene and mutation thought to be responsible for PD in this family and other, Greek families.[94] A base pair substitution in the α-synuclein gene was found in affected members in these families but not in unaffected individuals or patients with sporadic PD. The function of the protein encoded by this gene is unknown; however, it is hypothesized that its mutated version clumps together in nerve terminals causing cell death. Although this mutation is thought to explain only a small fraction of familial PD cases, it is hoped that the discovery can provide clues in the other cases of PD.

Numerous other genes have been the subject of studies attempting to link inherited factors with PD. The cytochrome P450 family of enzymes is responsible for detoxifying many drugs and environmental agents.[95] Debrisoquine hydroxylase (CYP 2D6) is polymorphic in nature and results in different levels of metabolism from person to person. It is hypothesized that if exposures to

environmental agents play a role in PD, abnormalities in detoxifying these agents may increase the risk of disease. This abnormality would increase the amount of toxin available to act on various points in the oxidative stress model.

Earlier studies assessed subjects' phenotypes by orally administering debrisoquine and measuring the amount of metabolite in urine. Subjects were labelled as extensive metabolizers or poor metabolizers, depending upon the percentage recovery of debrisoquine. Since no studies of white subjects revealed a significant OR[96–102] among poor metabolizers, studies focusing on individuals' genotype were conducted. These latter studies involved direct analysis of the CYP 2D6 gene and the determination of the specific variant associated with the poor metabolizer phenotype. The studies were very inconsistent in both their results and in the number of variants included in the genetic analysis. Although the results concerning the relation between PD risk and the most common variant, CYP 2D6B,[103–112] did not offer any conclusive evidence as to whether the CYP 2D6 gene is associated with PD, it may still play a role in a subset of individuals. Other members of the cytochrome P450 family, such as CYP 1A2 and CYP 3A4, may also be important in PD susceptibility.[113,114]

An association has been identified between the slow acetylator genotype for N-acetyltransferase 2 and familial PD.[115] This might increase the patient's susceptibility to environmental toxins; however, further study is required.

Mitochondrial gene defects

The activity of complex I, a group of proteins involved in aerobic respiration, has been observed to be deficient not only in the brain tissue of PD patients[116–118] but also in hybrid cells,[119] skeletal muscle,[120,121] fibroblasts[122] and, in some studies, platelets.[123,124] Complex I has also been found to be inhibited by the active metabolite of MPTP.[125] Since seven of approximately 40 subunits of complex I are encoded by mitochondrial DNA[126] and since this DNA is more easily damaged than nuclear DNA,[127] alterations in the mitochondrial genome, whether inherited or acquired through toxic agents, may be central to neurodegeneration in PD.

Studies involving mitochondrial DNA mutation analysis first reported a large deletion of genetic material in PD patients.[128] Later studies, however, downplayed these results and suggested that this deletion was an age-related observation, independent of PD.[129–131] Although other mitochondrial gene defects have been found in the brains of PD patients,[132–135] many of these study designs have failed to control for age. Since mitochondrial DNA is exclusively maternally derived, maternal inheritance of PD would be expected if mitochondrial DNA were associated with the disease.

Two studies[136,137] that have specifically investigated maternal inheritance are divided as to whether their evidence supports the hypothesis that inheritance of an abnormal gene is responsible for familial PD. The study that did not support the hypothesis[136] simply compared the number of fathers and mothers of PD patients who also had the disease, whereas the study that supported the hypothesis[137] included only those families in which both a parent and multiple siblings had PD. The authors of the latter study argue that simple pedigree analysis may not be sensitive enough to detect a preponderance of maternal inheritance.

Genetic anticipation, a phenomenon in which the severity of disease increases in subsequent generations, has been reported for a number of families with a history of PD spanning multiple generations.[89,138,139] This observation is thought to be related to the expansion of trinucleotide repeats, as is the case in diseases such as Huntington's disease and myotonic dystrophy.[140] However, no difference in trinucleotide repeat expansion was detected in PD patients and controls[140,141] or between generations in PD families that displayed anticipation in age at onset.[140] The pedigree analysis of one large kindred suggested that the observation of anticipation may be associated with an age-related ascertainment bias.[88]

Since PD is thought by some researchers to be similar to Alzheimer's disease (AD),[142,143] the apolipoprotein E (ApoE) gene, which is linked to AD susceptibility,[144–147] has been the focus of other genetic epidemiologic studies. With the exception of one study that reported a higher frequency of ApoE $\epsilon 4$ in PD patients with dementia than in those without dementia,[148] the $\epsilon 4$ allele has been found to be unrelated to PD.[149–156]

Numerous other genetic and molecular endpoints have been recently examined. Negative results have been reported from studies involving superoxide dismutase,[157] dopamine receptors[158] and tyrosine hydroxylase,[159] whereas there have been positive results for lactoferrin receptors,[160] L-cysteine,[161,162] catalase activity,[163] nitric oxide[163,164] and catechol-O-methyltransferase.[165] One study examined linkage for numerous genes simultaneously in three families with autosomal dominant inherited parkinsonism.[166] Although in one family there were slightly positive results for CYP 2D6, there was evidence against linkage genes for glutathione peroxidase, tyrosine hydroxylase, brain-derived neurotrophic factor, catalase, amyloid precursor factor and copper zinc superoxide dismutase. As with environmental factors, there may be many genes that play a role in PD pathogenesis. Genetic susceptibility may limit the patient's ability to detoxify otherwise innocuous environmental factors and thereby lead to the degradation of dopamine-containing neurons in the nigrostriatal system.[167]

Monoamine oxidases

Monoamine oxidases (MAOs) are degradative enzymes involved in the metabolism of toxins (A and B types)[32,168–170] and in the production of free radicals and hydrogen peroxide through the breakdown of dopamine (B type).[171–173] As with the genotypic CYP 2D6 studies, studies focusing on MAOs are very inconsistent. Although some show a relation between PD and a polymorphism of the gene encoding MAO type A and not B, and others show a relation between the disease and an MAO type B and not A polymorphism (Table 9),[174–179] the evidence seems to suggest that MAO enzyme variability may influence PD pathogenesis and progression.

One of the first gene**S**environment interaction studies in PD research involved an MAO-B polymorphism and smoking.[180] The study found an overall protective effect for smoking in PD similar to the results discussed previously. However, it further discovered that the inverse association was only present in individuals with a certain MAO-B variant. This breakthrough not only adds a genetic hypothesis to the list of ideas as to how and why smoking is protective, but it also emphasizes the importance of both genetic and environmental factors in PD etiology.

Diagnosis

A PD diagnosis is not necessarily clear cut, since there is no single diagnostic test.[3,181] In order for the condition to be diagnosed, physical examination should reveal two of either tremor, rigidity or bradykinesia. All other causes and types of parkinsonism must be excluded. The criteria for a diagnosis of PD also include a positive response to dopaminergic drugs such as levodopa. PD may also be described in terms of its severity. Hoehn and Yahr stages express the extent of an individual's disability on an arbitrary scale with five levels. Stage I consists of unilateral involvement only, usually with minimal or no functional impairment; Stage V consists of confinement to bed or wheelchair unless aided.[182]

As well, it has been reported that more than one quarter of PD patients exhibit dementia and that some patients with AD show signs of parkinsonism.[183] According to the *Merck Manual of Geriatrics*, a "clinical diagnosis is usually based on whether the motor signs were present before or after the cognitive decline".[183]

PD can only be diagnosed in an individual once symptoms have developed; approximately 70% of neurons in the substantia nigra have been lost when symptoms first occur.[6] This suggests an asymptomatic period in which the disease is progressing but the individual does not show any clinical signs. It would be advantageous, therefore, to develop a method of screening that would identify individuals at the earliest stage of neurodegeneration. Intervention would then focus on arresting the disease process rather than the current situation of primarily treating the symptoms. Although it is not known whether PD can be detected before symptoms are present, numerous strategies have been proposed.[184] Studies involving positron emission tomography (PET), movement time and the electrophysiological characteristics of tremor show that these methods may be useful in measuring preclinical dysfunction.

TABLE 9

Studies investigating the relation between monoamine oxidase (MAO) and Parkinson s disease (PD)

Study authors	Findings
Costa et al.[179]	Differences in allele frequencies of MAO-B leading to elevated odds ratios (ORs) for the G allele in males and females OR was significant in females
Ho et al.[176]	No difference in allele frequencies for MAO-B
Hotamisligil et al.[175]	Significant difference in allele frequencies for both MAO-A and MAO-B
Kurth et al.[174]	Significant difference in allele frequencies between cases and controls for MAO-B leading to an elevated and significant odds ratio for the G allele No difference in allele frequencies for MAO-A
Morimoto et al.[177]	No difference in allele frequencies for MAO-B in Japanese PD patients The G allele was twice as frequent in Caucasians than in Japanese
Nanko et al.[178]	No difference in allele frequencies for either MAO-A or MAO-B

Treatment

Although there is no cure for PD, both pharmacological and surgical treatments are available.

The main treatment for PD is pharmacological and includes different drugs designed to either increase the amount of dopamine in the brain or suppress the overactive cholinergic system (anticholinergics).[185–188] As dopamine cannot cross the blood**S**brain barrier, an alternative to administering this neurotransmitter was first introduced in the 1960s with levodopa.

Levodopa, a precursor to dopamine, has long been the standard treatment of PD; however, it causes adverse effects such as nausea, vomiting and orthostatic hypotension. Although there seems to be wide agreement that levodopa increases survival rates, there is some debate as to when this therapy should be started.[189] Levodopa therapy initially works well, but after several

years the majority of patients have either developed response fluctuations (wearing off and on-off phenomena) or dyskinesias (abnormal involuntary movements).[189] Those who assert that levodopa therapy should be started during the early course of the disease maintain that these motor complications reflect the progression of the disease, whereas those who argue in favour of delaying the drug believe that levodopa may cause toxic effects.

Other drugs, such as dopamine agonists, anticholinergic agents and amantadine, have been introduced as adjuncts to levodopa, their main function being to minimize its adverse side effects. Other negative effects, however, have emerged. For at least the past decade, selegiline, a selective inhibitor of MAO-B, has been the subject of controversy in PD treatment.[190–192] There is the question as to whether this drug has a neuroprotective effect on PD or simply a symptomatic effect.

An extensive review of pharmacological treatment approaches is beyond the scope of this Monograph Series; thus, the reader is referred to existing in-depth reviews.[193,194]

In addition to drug therapy, there are three surgical procedures used for the treatment of PD.[195,196] These are ablative surgery, deep brain stimulation and fetal tissue transplantation.

Ablative surgical procedures involve placing a lesion in a circuit of either the globus pallidus (pallidotomy) or the thalamus (thalamotomy). Since dopamine normally modulates an inhibitory influence of the basal ganglia to the thalamus, a dopamine deficiency would result in less inhibition. A lesion would correct this situation in that it would mimic dopamine in terminating nerve signals from the globus pallidus to the thalamus. Thalamotomies have been found to be successful for individuals with severe tremor. Although pallidotomy is effective in relieving bradykinesia and severe "off" motor disability, further study is required to assess the adverse effects of the surgery.[197]

Deep brain stimulation (DBS) is similar to ablative surgery but, rather than a lesion being created, a stimulating electrode is placed in the target. A recent study indicates that DBS and thalamotomy are equally successful in relieving tremor but suggests that DBS is preferable because of the ability to alleviate side effects and control tremor recurrence without further surgery.[198]

Fetal tissue transplantation has also been performed in some PD patients. This procedure involves implanting fetal dopamine-producing tissue into the basal ganglia in the hope that this tissue will develop and continually produce dopamine in the patient. Despite progress, these procedures are still very experimental and have only been performed in a limited number of individuals with a small amount of time devoted to follow-up.

Research, development and trials for more effective drugs with fewer side effects are ongoing. Parkinsonian symptoms can also be managed to a limited extent through dietary modification[199] and specific exercises.[200] Since PD patients vary with respect to their symptoms and disease severity, individuals will respond differently to the same treatment. Health care professionals must thus work alongside their patients to devise the best possible care.

Prognosis and Co-morbidity

The introduction of levodopa has increased survival rates in PD patients. A recent study[201] showed that survival was markedly improved with its use. The benefits were only seen, however, if levodopa therapy was initiated in the earlier stages of disease. Although survival rates have increased with levodopa and other therapies, PD patients are still at increased risk of dying as compared with individuals of similar age. A cohort study of parkinsonian patients in England and Wales revealed that these patients had more than a twofold risk of dying compared with general population controls after 20 years of follow-up,[202] with very little difference between males and females. A similar study conducted in Scotland found a similar relative risk of 2.5, but this was only for 3.5 years of follow-up.[203] Two US studies calculated relative risks of 2.7 over a mean follow-up of 2.5 years[204] and 2.0 over a mean follow-up of 9.2 years.[205] A higher mortality rate was recorded for institutionalized individuals with PD than for those without it in one study,[206] but not in another one.[26]

In one of the studies mentioned, the risk of death increased with increasing number of parkinsonian signs present.[205] The presence of gait disturbance specifically was found to be associated with increased mortality risk. These observations must be interpreted with caution, since some of the studies included subjects with all forms of parkinsonism. In a study involving only subjects with PD, the duration from disease onset to Hoehn and Yahr stages I, II, III, IV and V were 4.0, 6.5, 7.9, 9.8 and 11.8 years, respectively.[207] Patients who noticed unilateral symptoms initially had a better prognosis than those who first noticed bilateral symptoms. Seventy percent of all patients noticed unilateral symptoms initially, of which 91% spread to the other side. Louis et al. found that the severity of extrapyramidal signs was the single most important indicator of increased mortality in PD patients.[204]

PD patients also differ from the general population in terms of their specific cause of death. Some studies have found that individuals with PD are more likely to die of ischemic heart disease,[202,207] cerebrovascular disease,[202,204,208] pneumonia[204,208,209] and other respiratory diseases.[202] The reasons for these differences are not known but may involve competing causes of death, a secondary effect of treatment or common etiology.[202] Cancer mortality has been found by some to be

significantly lower in PD patients than in an age- and sex-matched population.[204,208] However, this is only true for cancers that are thought to be related to smoking and is explained by the fact that PD patients are less likely to smoke.[210]

Depression

Depression has been found to be more prevalent in individuals suffering from physical illnesses such as stroke, cancer and endocrine and metabolic disorders.[211] The few recent studies that have examined the relation between depression and PD have been very inconsistent. This variability is largely due to the different criteria used to measure depression. Recent studies, however, have agreed that depression is more common in PD patients with dementia than patients without dementia.[212–215] Depression in PD patients was also found to be related to thought disorders[215] and autonomic failure.[216] Inconsistencies have been noted for the relation between depression and age, disease course and impairment in the activities of daily living.[214,215,217,218]

Conclusions

Implications for an Aging Population

Since the proportion of both Canada's and the world's population that is over 65 years of age will increase dramatically over the next three decades, the number of individuals with PD is expected to increase correspondingly. In fact, the percentage of Canada's population over the age of 65 is expected to increase from 11.6% in 1991 to 23.6% by the year 2016.[219] This translates into an 87% increase in the number of individuals requiring medical care on an in-patient basis and a 92% increase in the number of individuals dying from PD. The change will be greatest in the oldest age groups, in which the number of individuals affected with PD is expected to more than double.

Future Research

Although the past few years of PD research have been very productive, many questions remain.[220] The identification of biological markers for PD will play an integral part in future research. This will enable researchers and physicians to diagnose the disease more accurately, develop treatments that slow or arrest disease progression once it has started and initiate steps towards preventing the disease. It would also allow individuals known to be at higher risk to be monitored before symptoms appear. Genetic research may lead to the identification of other genes that predispose individuals to PD, and further investigation of the role of environmental risk factors could supply important information for the development of prevention strategies. An understanding of the interplay between environmental and genetic factors could provide the key to future advances in PD research.

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Development of Record Linkage of Hospital Discharge Data for the Study of Neonatal Readmission

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Abstract

Computerized record linkage has been used increasingly in epidemiologic studies. We developed a multi-stage, deterministic matching algorithm using various combinations of key variables. Then, from the records for March 1, 1993, to March 31, 1996, contained in the discharge abstract database of the Canadian Institute for Health Information (CIHI), we examined the relation between length of hospital stay at birth and neonatal readmission. A combined use of province/territory of occurrence, 6-digit postal code of residence, date of birth and sex (step 1) matched 88.5% of 26,629 eligible neonatal readmission records with their birth records. Additional use of institution code and chart number or health card number combined with date of birth and sex (step 2 and step 3) increased the matching rate to 93.0%. Compared with the gold standard, step 1 correctly matched 94.4% of the records. We conclude that this deterministic matching algorithm is a feasible and convenient approach to data linkage for the study of neonatal readmission. The linkage strategy may also be helpful in epidemiologic studies of other short-term events.

Key words: *epidemiologic method; hospital discharge abstract; medical record linkage; neonatal readmission*

Introduction

Studies of existing databases are attractive to epidemiologists and other health researchers because they can be done efficiently at the level of large populations. For example, it is possible to examine the relation between birth weight, gestational age, maternal age and infant mortality or morbidity at the country level by analyzing existing data, as the information is routinely recorded in vital and hospital statistics. However, the lack of comprehensive information in a single database often impedes researchers in this effort. In recent years, the development of computerized record linkage has made it possible to overcome such obstacles in existing database studies.[1S17]

Record linkage methods can be summarized into three broad categories: manual, deterministic and probabilistic. Manual matching is the oldest, most time-consuming and most costly method, but remains the standard. However, it is not a feasible option when large databases are involved. Probabilistic linkage is used to identify and link records from one data set to corresponding records in another data set (or two records from different locations in a single data set) on the basis of a calculated statistical probability for a set of relevant variables (e.g. name, sex, date of birth). Deterministic linkage matches records from two data sets (or two records from different locations in a single data set) using a unique variable (e.g. social insurance number or hospital chart number) or by full agreement of a set of common variables (e.g. name, sex, birth date).

Probabilistic linkage is considered the preferred method, because the calculation of the probability can be refined in various respects to accommodate weights associated with identifier values and coding errors, thus maximizing the available information in the data.[1S3,16,17] However, the probabilistic linkage requires detailed prior knowledge about various measures of the relative importance of specific identifier values—for example, frequency—in both files that are to be linked. Investigators often do not have this degree of prior knowledge.[6]

This paper aims to illustrate the use of deterministic linkage of hospital discharge records in the hospital

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discharge database of the Canadian Institute for Health Information (CIHI), taking neonatal readmission as an example. One of our previous studies revealed a substantial recent reduction in length of newborn hospital stay at birth.[18] We hypothesized that this reduction might increase rates of neonatal readmission. To allow an examination of the relation between length of newborn hospital stay at birth and subsequent neonatal readmission, a linkage of readmission record with the infant's own birth record is required.

Methods

Three years of CIHI data (fiscal years 1993/94 to 1995/96) were used. Data for Nova Scotia, Quebec and Manitoba were excluded because CIHI collected only a small proportion of hospital discharge records in these provinces.[19] Live infants were identified by a field of "age unit" with a code of "NB." Infants weighing less than 1500 g, those discharged from hospital after 21 days from birth and those who subsequently died in their hospital of birth were excluded. A neonatal readmission was defined as admission of an infant to any hospital, within 28 days of birth. Infants who were transferred from another institution were not included as readmission cases. Multiple births were excluded from both birth and readmission records because non-identifiable variables were shared among them.

Both birth and readmission records have information on province/territory and institution of occurrence, institution chart number, date of birth, sex, provincial health card number, 6-digit postal code, admission date, discharge date and diagnostic codes. Institution code, institution chart number and provincial health card number are scrambled for confidentiality considerations (Table 1).

Theoretically, the health card number and/or institution chart number, although scrambled, can be used as a unique variable for record linkage because the same number is used for each individual once it has been assigned by the provincial/territorial authority or hospital. However, because of delay in obtaining the health card number, infants are usually assigned their mother's number or that field is left blank at birth. We were concerned that using the health card number alone might lead to confusion or error if infants were subsequently given their own number or shared a number with their siblings. The institution chart number is effective only when an infant is readmitted to the hospital where he or she was born; only a small proportion of cases were readmitted to the hospital of their birth, however.

Accordingly, we considered it appropriate to use a set of variables for multi-stage deterministic linkage. Based on our assessment of the availability and appropriateness of the variables on CIHI discharge records, a computer matching algorithm was designed. As described in Figure 1, records of birth and readmission were matched first by full agreement of province/territory of occurrence, 6-digit postal code of residence, date of birth and sex (step 1); second, by full agreement of institution code, institution chart number, sex and date of birth (step 2); and third, by full agreement of provincial/territorial health card number, sex and date of birth (step 3); finally, matching was supplemented by a logic check of the matched cases (step 4). The logic check involved determining whether there were conflicts or contradictions between birth date, discharge date, readmission date and age at readmission.

To evaluate the accuracy of the record linkage carried out in step 1, on which the majority of the successful matches were based, we created a linked file by using step 2 alone to identify the infants who were readmitted to the hospital of birth. We considered this linked file as the gold standard, because the institution chart number is unique in these records. We then separated the linked birth and readmission records, and performed step 1 to link them again in order to assess its matching accuracy as compared with that of the gold standard.

Finally, we assessed the potential bias caused by exclusions and unsuccessful linkage by comparing the distributions of variables of interest, such as birth weight, length of hospital stay and main diagnostic categories for readmission, between the linked and unlinked cases. In this comparison, the unlinked cases included those who were excluded according to the selection criteria before the linkage procedure was performed. SAS software for Unix, version 6.12 (SAS

TABLE 1

Availability of proposed matching variables for record linkage in birth file and in neonatal readmission file

Variable	Birth file	Readmission file
Number of records	788,480	27,405
Province (%)	100.0	100.0
Institute number (%)	100.0	100.0
Chart number (%)[a]	97.4	98.2
Health card number (%)[b]	86.8	80.6
Postal code (%)[c]	97.9	98.0
Residence code (%)	70.1	71.0
Date of birth (%)	100.0	100.0
Sex (%)	100.0	100.0
Admission date (%)	100.0	100.0
Discharge date (%)	100.0	100.0

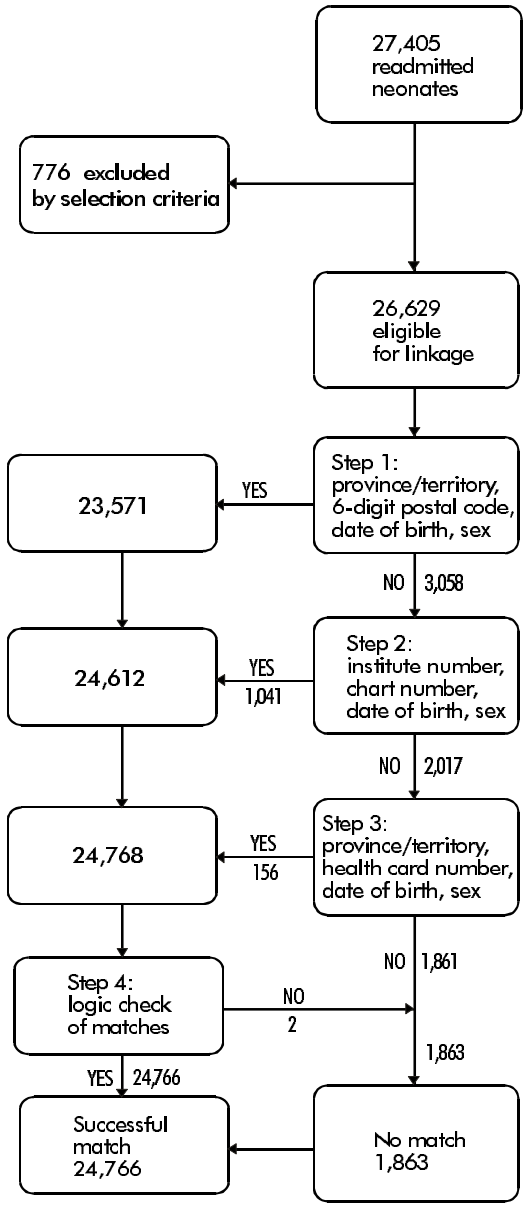
[a] Different institutions have different chart number series. Only an infant who is readmitted to the same hospital of birth is assigned the identical chart number.

[b] It was found that a majority of infants were assigned their mothers health card number at birth or at readmission.

[c] About 1% of records showed no information on postal code; another 1% contained incomplete 6-digit postal codes in both files.

FIGURE 1

Matching algorithm for record linkage of hospital discharge data



Institute Inc., Cary, North Carolina), was used in all data abstraction and linkage processing.

Results

A total of 817,351 live infants were born in hospitals in the nine Canadian provinces and territories studied and were recorded by CIHI during the period of March 1, 1993, to March 31, 1996. After excluding infants who weighed less than 1500 g, who were discharged from hospital after 21 days from birth, who subsequently died in hospital or who were part of multiple births, we found 798,840 live birth records that met the inclusion criteria. During the corresponding period, a total of 27,405 infants in the same nine Canadian provinces and territories were readmitted to hospitals within 28 days of birth. According to the selection criteria, 26,629 of these readmissions were eligible to be linked with birth records.

Step 1 successfully matched 23,571 readmitted infants (after excluding 26 duplicates) to their birth records, accounting for 88.5% of the 26,629 eligible readmission cases. Implementation of steps 2 and 3 increased the successful matches to 24,766 readmission cases, representing 93.0% of eligible readmission cases, after two pairs were excluded by step 4 (logic check). Details of the matching process are given in Figure 1.

Among the 7430 cases in the linked file used as the gold standard, 7023 (94.5%) cases were successfully matched by implementation of step 1 as described in Figure 1. Of these 7023 cases, 2 cases were falsely matched and 7 were duplicates, as a result of their non-identical matching variables. Therefore, the correct matching rate was 94.4% using step 1, i.e. full agreement of province of occurrence, 6-digit postal code of residence, sex and date of birth.

Comparison of linked and unlinked cases showed that they were quite similar in main characteristics and diagnoses of interest (Table 2). However, statistically significant higher proportions of infants of low birth weight (6.4% versus 5.6%) and readmissions with a diagnosis of jaundice (40.9% versus 38.6%) were observed in unlinked cases. There was also an increase in the rate of successful record linkage from fiscal year 1993/94 to 1995/96 (Table 2).

Discussion

Probabilistic matching is a recommended strategy for computerized record linkage. It is considered the preferred method because the calculation of the probability can be refined in various respects to accommodate weights associated with identifier values and coding errors, thus maximizing the available information in the data.[1S3,16,17]

If there is a common unique identifier (e.g. social insurance number) in both files to be linked, and if the common unique identifier is quite accurately recorded in the data, deterministic linkage can be performed conveniently by using routine statistical software such as SAS. However, such a common unique identifier is often not available. For example, social insurance numbers or other personal identifiers are often issued to adults only, so that they cannot be used in studies involving infants and children. For confidentiality considerations, the data collector is often prohibited from releasing the subject's name. Even if the subject's name can be released to investigators, spelling mistakes in names are frequent.[15]

TABLE 2

Comparison of main characteristics of linked and unlinked cases in a study of neonatal readmission

Characteristic	Linked cases	Unlinked cases[a]	*p* value
Number	24,766	2,639	
% of fiscal year 1993/94	30.8	35.2	<0.01
% of fiscal year 1994/95	33.4	33.2	NS
% of fiscal year 1995/96	35.8	31.6	<0.01
% of males	57.0	56.3	NS
% of birth weight <2500 g	5.6	6.4	<0.01
Mean age at readmission (days)	10.8	10.7	NS
% of length of stay <2 days at birth	25.6	25.8	NS
% of infants with jaundice	40.9	38.6	<0.05
% of infants with dehydration	5.9	6.1	NS
% of infants with inadequate weight gain	2.8	2.4	NS
% of infants with feeding problems	9.8	10.2	NS
% of infants with sepsis	5.4	5.3	NS

[a] The number includes the cases that were excluded prior to linkage procedure by subject selection criteria.

NS = Not significant

Postal code is a well-developed system of Canada Post Corporation. This information is often recorded completely, and the chance of a mistake is relatively low, as the code tends to be shorter and simpler than name and address. In addition, because it does not reveal an individual's identity, it can be fully released to investigators without confidentiality concerns. We performed a frequency procedure on our raw data, and found that the chances of two individuals sharing the same sex, date of birth and 6-digit postal code were very low (data not shown). With combined use of sex, date of birth and other information, this variable can play a key role in identifying the same individual. This procedure (i.e. step 1) accounted for the majority of the linked records (88.5%) in our study of neonatal readmission; as well, it was quite accurate (94.4% as compared with the gold standard). In Canada, a small proportion of births occur outside of hospitals. If we had access to data on out-of-hospital births, the matching rate would be even higher.

As with other linkage methods, the success of deterministic linkage depends largely on the completeness and accuracy of the information in the files to be linked and an appropriate combination of matching variables. In our linkage procedures, failure in matching was largely caused by missing or incomplete information on the variables used, such as postal code. However, as suggested by the increasingly successful matching rates from year 1993/94 to 1995/96 (Table 2), the quality of CIHI hospital discharge data is improving, and this provides promise for future studies using deterministic linkage.

When failure in linkage occurs, it is important to assess its potential impact on the study results. One consequence is that the sample size available for analysis will be reduced. However, because sample size is usually not an issue in existing database studies, the real concern of incomplete record linkage is the potential bias introduced by unsuccessful linkage. Our comparison of linked and unlinked cases showed no substantial differences in main characteristics and diagnostic categories of interest (despite statistically significant differences in low birth weight and jaundice rates), suggesting that no major bias was introduced by this record linkage.

One limitation of record linkage using postal code as a key matching variable should be emphasized. In modern society, people relocate quite frequently. As a result, deterministic record linkage involving postal code may be less reliable in studies of long-term events. In our case, the chance of relocation within 28 days after birth was low, unless the patients gave different addresses at different hospital admissions (e.g. gave parents' address at birth but grandparents' address at readmission). In addition, relying on full agreement of a set of matching variables often restricts some potential matching pairs or reduces the sensitivity.

The deterministic matching algorithm provided a feasible and convenient approach to data linkage for our study of neonatal readmission. Although it was developed for a specific purpose, it may also be used for epidemiologic studies of other short-term events, such as epidemic outbreak, rehospitalization, adverse drug or vaccine reactions and familial aggregation of disease or

risk factor. For example, with some modifications of the linkage program, it may be used to study maternal readmission or the relation between maternal characteristics and infant outcomes.

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Rate and Cost of Hospitalizations for Asthma in Quebec: An Analysis of 1988/89, 1989/90 and 1994/95 Data

Claudine Laurier, Wendy Kennedy, Jean-Luc Malo, Michèle Paré, Daniel Labbé, André Archambault and André-Pierre Contandriopoulos

Abstract

The objectives of this study were to evaluate recent trends in the frequency and length of stay of hospitalization for asthma in the province of Quebec and to estimate the costs of asthma hospitalizations. Data were extracted for persons hospitalized for 30 days or less with a primary diagnosis of asthma in all Quebec short-stay hospitals during the years 1988/89, 1989/90 and 1994/95. There were 1.76 asthma hospitalizations per 1000 persons in Quebec in 1988/89, down to 1.44 in 1989/90 and up again to 1.75 in 1994/95. There was a small decrease in mean length of stay when the three data years were compared. In all three years, the rate of hospitalization was particularly high among young boys. In 1994/95, more hospitalizations occurred during the fall months. We estimated the total cost for asthma hospitalization that year to be $18 to $21 million.

Key words: *asthma; costs; hospitalizations; Quebec*

Introduction

Asthma is a common disease of both adults and children, causing breathing impairment with consequences dependent on the severity of the disorder. Studies have estimated the population prevalence as 3%[1] and 7%[2] in the adult population and over 10% in children.[3] According to the 1987 Santé Québec survey, the prevalence of asthma, bronchitis and emphysema (as one comprehensive category) was 3.9% in the general Quebec population.[4] Santé Québec has published the prevalence by sex (4.1% among women and 3.9% among men) and by age group for some groups: 4.1% among those aged less than 15 years, 3.2% among those 15**S**24, 4.4% among those 45**S**64 and 7.1% among those 65 and older.[4]

Rates of Quebec hospitalizations for asthma increased during the decade from the early 1970s to the early 1980s, by 79% to 1.56 per 1000 among males and by 58% to 1.33 per 1000 among females.[5] The early 1980s may have seen a decrease: in 1984/85 there were 9080 hospitalizations for asthma in Quebec, down from 11,726 in 1980/81.[6] Over the entire 1980s there was an average increase in the annual rate of hospitalizations of 3.3%.[7] In Canada, the number of hospitalizations increased at an average rate of 1.8% per year from 1981 to 1989, and the mean length of stay decreased from 6 to 4.7 days over the same period.[8] Hospitalization rates differed across age groups—in 1988 the estimated rate was 5.82 per 1000 among those under 15 years old and 0.66 among those aged 15 to 34.[8] Asthma hospitalization was subject to a substantial seasonal influence, the rate peaking in autumn.[9, 10]

The preceding data describe the situation in the 1980s. With the increase in use of inhaled corticosteroids (from 6 per 1000 Saskatchewan inhabitants in 1989 to 20 per 1000 in 1993[11]), reflecting the dissemination of guidelines and recommendations for treatment of asthma, there could be a decrease in the need for

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hospitalization due to asthma. Such a decrease was seen recently in Sweden.[12] Offsetting this expected trend is the increase in the prevalence of asthma that is generally agreed to be taking place.[13]

Inasmuch as the cost of asthma treatment is important, relatively up-to-date estimates of the cost of hospitalization for asthma—a major component of overall costs—are of interest. The direct costs of asthma in Canada for 1990 were estimated to be $306 million; hospital in-patient care was an estimated $84.4 million, excluding drugs.[14]

To explore the hypothesized changes in rates of hospitalization and to estimate the cost of this area of asthma treatment, we examined rates of hospitalization with a primary diagnosis of asthma for the Quebec population during three one-year periods: 1988/89, 1989/90 and 1994/95. Rates and average lengths of stay of such hospitalizations were established, and those for 1994/95 were examined according to age, sex and month of admission. The costs associated with the 1994/95 asthma hospitalizations were then estimated.

Methods

This study used the MED-ECHO database for fiscal years 1988/89, 1989/90 and 1994/95 (i.e. from April 1 until March 31 for each year). MED-ECHO is an electronic database that contains detailed hospitalization summaries. The database includes information on the principal diagnosis and up to 16 associated diagnoses, dates of admission and separation, length of stay, ward, major procedures undergone as well as the age and sex of the patient. All hospitalizations with the principal diagnosis of asthma (ICD-9 codes 493.0 to 493.9) were retrieved for the relevant years. As MED-ECHO annual files are organized according to date of separation, the hospitalizations analyzed in this study included those in which the patient was admitted during the previous period but discharged in the period of study. On the other hand, hospitalizations for patients admitted during the period of study but discharged in the subsequent period were not included. Less than 1% of retrieved hospitalizations were in long-stay hospitals or were for a period of greater than 30 days. These long-stay hospitalizations were excluded from the analysis, as they were likely to be related to conditions other than simple asthma.

Population data represented the population eligible for the Health Insurance Program on July 1st of the respective year (1989, 1990 and 1995) and was lower by about 86,000 than the total estimated population of roughly 7 million.[15] It should be noted that MED-ECHO reports the number of hospitalizations and not the number of people hospitalized in any given period. The rates presented here must be interpreted accordingly.

Rate of hospitalization per 1000 and length of stay were estimated by age group and sex for the three one-year periods. Age (in years) was grouped as follows: less than 1, 1**S**4, 5**S**9, 10**S**14, 15**S**19, 20**S**39, 40**S**64, 65**S**74, and 75 and older. The 1994/95 hospitalization rates were also analyzed by month of admission. Differences in the average length of stay among patients according to the month of admission, age group and sex were tested for significance using parametric or non-parametric tests (*t*-test, analysis of variance [ANOVA] or Kruskall-Wallis). A two-way ANOVA was performed for age and sex.

The cost of asthma hospitalization was estimated by means of two methods. The first used the 1994/95 financial data for all short-stay hospitals (excluding psychiatric hospitals). A per diem specific to the hospital ward was calculated, which included nursing care, pharmacy, laboratory, "hotel," administration and maintenance costs; it excluded capital cost investment and physician reimbursement. The recorded length of stay was multiplied by the per diem.

The second approach used an index reflecting the relative use of resources (NIRRU) for each hospitalization classified according to its All-Patient Refined Diagnostic-Related Group (APR-DRG).[16] These APR-DRGs constitute 1530 groups of clinically homogeneous patients requiring an equivalent level of resources. They are based on diagnosis, severity and probability of poor outcome. Among other changes to the previous versions of the DRG classifications, the APR-DRG system has incorporated certain specific pediatric DRGs. For each APR-DRG, a NIRRU was created.

The NIRRU was based on costs per APR-DRG for typical patients established in Maryland in 1994. The cost for each APR-DRG was divided by the mean cost for all hospitalizations to obtain a relative weight, where 1.00 corresponded to the mean. This index was then adjusted to take into account the differences in lengths of stay between Maryland and Quebec (see Appendix). A NIRRU was calculated for each asthma hospitalization and was applied to the average cost of hospitalizations in the province of Quebec for 1994 to establish a cost per asthma hospitalization.

Total and average costs for all asthma hospitalizations were estimated using both methods, and 95% confidence intervals were calculated for average costs per NIRRU-adjusted asthma hospitalization.

Results

Hospitalization Rates for Asthma

From 1989 to 1995, the population of Quebec eligible for health benefits increased by 4.1%, from 6.91 million to 7.19 million. The rate of the total number of hospitalizations less than 30 days (for any reason) at the end of that period was 14.8% higher than at the beginning, increasing from 142 per 1000 in 1988/89 to

163 per 1000 in 1994/95. The proportion of Quebec hospitalizations associated with asthma as the principal diagnosis was 1.1% in 1994/95, slightly lower than in 1988/89 (1.2%). The rate of hospitalization with asthma as the principal diagnosis was 1.76 per 1000 in 1988/89, fell to 1.44 in 1989/90 and rose to 1.75 in 1994/95 (Table 1).

Rates were estimated at 1.85 per 1000 among men and 1.67 per 1000 among women in 1988/89, falling to 1.79 and 1.71 per 1000, respectively, in 1994/95 (Table 1).

The hospitalization rate for children less than 1 year old in 1994/95 was twice as high as in 1988/89 or 1989/90. In the 1**S**4 age group, it remained relatively the same but slightly lower than the 1988/89 figure.

Figure 1 shows that hospitalization rates for asthma in 1994/95 were highest among male infants under the age of 1 year, and high among boys aged 1**S**4. As well, boys under 5 were hospitalized at a rate roughly twice that of their female counterparts. In the age groups of 10 years and older, however, the rates among women were higher, and females aged 20**S**39 were hospitalized at roughly twice the rate of their male counterparts.

For 1994/95, the hospitalization rates for asthma were higher in the autumn and winter months (from September to December) and lower in the summer months (from May to August), particularly in the holiday months of July and August (Figure 2).

Length of Hospital Stay

The average length of stay for asthma hospitalizations decreased from one study period to another. Mean lengths of stay were significantly longer for women than men in all three periods. Mean length of stay for men decreased from 1988/89 to 1994/95. It stayed roughly the same for women in 1988/89 and 1989/90, but was lower in 1994/95.

FIGURE 1

Rates of Quebec hospitalizations with asthma as principal diagnosis (LOS ≤30 days), by age and sex, 1994/95

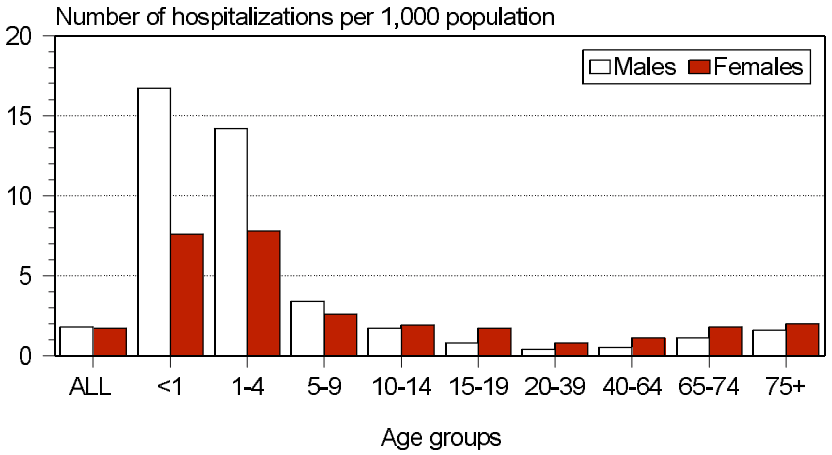

TABLE 1

Quebec hospitalizations (number and rate per 1000 population) with asthma as principal diagnosis (LOS ≤30 days) and mean length of stay (LOS), 1988/89, 1989/90 and 1994/95

Sex and age group	1988/89				1989/90				1994/95			
	n	Rate	Mean LOS	LOS 95% CI	*n*	Rate	Mean LOS	LOS 95% CI	*n*	Rate	Mean LOS	LOS 95% CI
TOTAL	12,166	1.76	4.27	4.20 4.34	10,217	1.44	4.13	4.05 4.21	12,604	1.75	3.75	3.69 3.81
Males	6,328	1.85	3.75	3.67 3.83	5,179	1.48	3.47	3.38 3.56	6,335	1.79	3.19	3.12 3.26
Females	5,838	1.67	4.83	4.72 4.94	5,038	1.41	4.81	4.68 4.94	6,269	1.71	4.31	4.21 4.41
<1	584	6.20	4.41	4.12 4.70	521	5.48	3.98	3.70 4.26	1,121	12.30	3.54	3.39 3.69
1 4	3,475	12.24	3.05	2.97 3.13	4,283	12.20	2.63	2.57 2.69	4,315	11.08	2.38	2.33 2.43
5 9	1,248	4.01	3.03	2.91 3.15	1,917	4.10	2.63	2.55 2.71	1,341	3.01	2.33	2.25 2.41
10 14	799	2.27	3.30	3.14 3.46	1,062	2.19	2.94	2.83 3.05	859	1.79	2.83	2.70 2.96
15 19	461	1.06	3.51	3.28 3.74	494	1.08	3.18	2.95 3.41	582	1.22	2.98	2.78 3.18
20 39	1,098	0.48	4.37	4.17 4.57	1,197	0.61	4.43	4.23 4.63	1,310	0.57	4.01	3.83 4.19
40 64	1,507	0.88	6.77	6.52 7.02	1,658	0.83	6.60	6.35 6.85	1,710	0.79	5.72	5.50 5.94
65 74	617	1.42	8.06	7.60 8.52	617	1.34	8.44	7.98 8.90	739	1.45	7.36	6.96 7.76

Mean length of stay also varied significantly with respect to age group ($p < 0.01$, chi-squared = 2874, Kruskall-Wallis). Data for all three periods showed a consistent pattern of relatively long duration for the youngest group (less than 1 year), declining to the shortest mean duration in the 5**S**9 age group, then increasing up to the longest stay in the 75+ age group (Table 1).

The two-way ANOVA revealed a significant interaction of age and sex on mean length of stay in 1994/95 ($p < 0.001$, $F = 21$). Mean lengths of stay and 95% confidence intervals (CIs) for age group and sex appear in Table 2. For boys and girls under age 5, mean lengths of stay appeared similar. Differences between men and women were significant in three age groups (5**S**9, 10**S**14 and 40**S**64).

The average length of stay in 1994/95 also varied significantly according to month of admission (Figure 2), being shorter for those admitted during the fall months ($p < 0.01$, chi-squared = 221, Kruskall-Wallis).

Cost of Hospitalizations for Asthma

The results of the cost estimation for asthma hospitalizations in Quebec for the year 1994/95 are presented in Table 3. For the first method of calculation, using the per diem for short-stay hospitals ($379),[17] the average 1994/95 cost per stay was approximately $1400 and the total cost was $17.9 million.

FIGURE 2

Quebec hospitalization rates with asthma as principal diagnosis (LOS ≤30 days) and average length of stay, by month, 1994/95

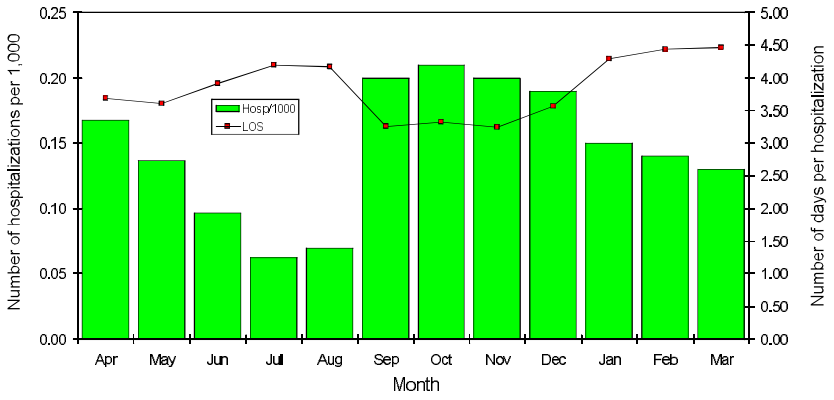

TABLE 2

Quebec hospitalizations with asthma as principal diagnosis (LOS ≤30 days) and mean length of stay (LOS), by age and sex, 1994/95

Age group	Hospital separations: MALES			Hospital separations: FEMALES		
	n	Mean LOS (days)	LOS 95% CI	*n*	Mean LOS (days)	LOS 95% CI
<1	783	3.57	3.38 3.74	338	3.49	3.21 3.77
1 4	2,824	2.40	2.33 2.47	1,491	2.36	2.28 2.44
5 9	766	2.23	2.13 2.33	575	2.46	2.34 2.58
10 14	410	2.55	2.39 2.71	449	3.09	2.88 3.29
15 19	188	2.72	2.43 3.01	394	3.10	2.83 3.37
20 39	443	3.88	3.59 4.16	867	4.08	3.85 4.31

A NIRRU was estimated for all 1994/95 short-stay asthma hospitalizations except 54 (0.4%). The average NIRRU for all the asthma hospitalizations was 0.6 (±0.003), and this varied according to the ward in which the patient was treated (Table 3). The average cost per stay was $1676 (95% CI = 1661**S**1692). Of the total cost of $21.0 million, the greatest proportion was accounted for by the Pediatrics ward ($9.9 million). The NIRRU-adjusted cost per stay was lowest in Allergy ($1397) and Pediatrics ($1,413) wards, where the average lengths of stay were shortest, and highest in Internal Medicine ($2150) and Other ($2348) wards, where the average lengths of stay were highest.

Discussion

Earlier studies found an increase in the hospitalization rate for asthma in Quebec from the early 1970s to the early 1980s.[5] The hospitalization increases during that period for all of Canada were greatest in persons under the age of 15.[5] From 1981 to 1988, the overall Canadian age-standardized rate of hospitalizations rose by roughly 40%. Although the rate in Quebec was lower than the national average, the increase was relatively high, at 70% and 77% for those under 15 and ages 15**S**35, respectively.[8]

Our data show that asthma hospitalization rates were lower in 1989/90 than in 1988/89. As well, mean length of stay was shorter in 1989/90 than in 1988/89. In 1994/95, a return to the 1988/89 level of asthma hospitalization rate was seen; however, the mean length of stay was shorter than in the preceding period. The decrease in

TABLE 3

Costs of Quebec hospitalizations with asthma as principal diagnosis (LOS ≤30 days), by hospital ward and calculation method, 1994/95

Hospital ward	Hospital separations				Costs: METHOD A[a]		
	n	% of total	Mean LOS	TOTAL DAYS	Cost per day	Cost per stay	TOTAL COST
Allergy	439	3.5	2.19	961	$379	$831	$364,817
Internal medicine	587	4.7	6.05	3,551	$379	$2,296	$1,347,595
Pneumology	1,862	14.8	5.70	10,613	$379	$2,163	$4,027,361
Pediatrics	7,039	55.8	2.60	18,301	$379	$987	$6,944,649
Medicine	2,475	19.6	5.08	12,573	$379	$1,928	$4,770,951
Other	202	1.6	6.19	1,250	$379	$2,349	$474,469
TOTAL	12,604	100.0	3.75	47,251	$379	$1,423	$17,929,842
Hospital ward	**Hospital separations**				**Costs: METHOD B[a]**		
	***n*[b]**	**% of total**	**Mean NIRRU**	**NIRRU 95% CI**	**Cost per stay**	**95% CI**	**TOTAL COST**
Allergy	439	3.5	0.497	0.484 0.511	$1,397	$1,358 1,436	$613,182
Internal medicine	580	4.6	0.766	0.729 0.803	$2,150	$2,047 2,253	$1,247,046
Pneumology	1,849	14.7	0.725	0.709 0.741	$2,037	$1,992 2,081	$3,765,525
Pediatrics	7,037	56.1	0.503	0.499 0.508	$1,413	$1,400 1,425	$9,941,170
Medicine	2,445	19.5	0.729	0.712 0.745	$2,046	$2,000 2,091	$5,001,394
Other	200	1.6	0.836	0.763 0.909	$2,348	$2,143 2,553	$469,552
TOTAL	12,550	100.0	0.597	0.592 0.603	$1,676	$1,661 1,692	$21,037,893

mean length of stay is consistent with that reported elsewhere for Canada.[18]

Our analysis has confirmed the differences according to age and sex that have been found in previous studies.[1,8] Longer mean hospital stays were associated with individuals less than 1 year old and those over 75. There was an interaction of the variables of age and sex with respect to length of hospital stay: mean stays were relatively similar until the age of 5, and after that the length of stay was often longer for girls and women. This could be explained by an association between average length of hospital stay and the presence of comorbid conditions, more frequent in older women. Indeed, hospitalizations with a secondary diagnosis were, on average, of longer duration (4.3 days, 95% CI = 4.17–4.34) than those without (2.6 days, 95% CI = 2.52–2.65).

As documented previously,[9,10] most asthma hospitalizations occurred in the fall and the fewest, in the summer. The reduced hospitalization rate in the summer was possibly partially due to holidays and hospital bed closures associated with health care staff reductions. The relatively high numbers in the fall may be associated with increased viral infections occurring near the beginning of the school year[19] and ragweed allergy season (from mid-August until the end of September),[20] the asthmatic individual tolerating the reaction for a certain length of time until hospital admission was necessary. An additional cause could be the increased time spent indoors during these fall months, with increased exposure to indoor allergens such as mites and domestic animals.

This seasonal peak does not appear to be an artifact of including patients with chronic obstructive pulmonary disease misdiagnosed as asthma (whose problems may increase in the fall months) because the increase, when analyzed by age group, seemed to be accounted for mostly by children under the age of 10. There was a small rise in the number of admissions in the 40**S**64-year-old group in September and October, but not in those aged 65 and over (data not shown).

Length of hospital stay was also associated with month of admission, in that the shortest stay was associated with fall admission and the longest with winter admission. Although at first glance this could reflect the availability of hospital beds, since the length of stay appeared to be inversely related to the number of admissions, it was probably more likely due to the increased numbers of hospitalizations of young children during the fall, with their concomitant shorter average stays.

The NIRRU-adjusted cost estimate was higher than that calculated from the average hospitalization cost. Most likely this was due to the ability of the NIRRU to account for the higher cost of days at the beginning of a hospitalization. Asthma hospitalizations are shorter, on average, than overall hospitalizations in Quebec, by almost 50%. Economic evaluations that apply average costs per hospital day could be underestimating the true cost.

The NIRRU index was based upon costs in Maryland, US, and this could limit its usefulness. It is assumed that although the absolute costs per APR-DRG could differ between Maryland and Quebec, the relative costs of one group compared with another should be the same. The adjustments for the Quebec situation did take into consideration differences in the average length of stay between Maryland and Quebec (Quebec hospital stays are normally longer) and the fact that the end of a hospital stay was less resource-intensive than the beginning. There are limitations, however, in using an index based on a different system: we cannot account for structural differences in costs, such as for nursing care and equipment, nor do we have information on the differences between the US and Canada in terms of the severity of the condition of patients admitted to hospital. Even with these limitations, the NIRRU does give us some advantages over a simple per diem, which does not account for differences in resource-intensity during the stay or for differences in severity of illness among patients.

Assuming that Quebec's hospitalizations represent 21% of those for Canada (based on the rate reported for 1989), the estimate by Krahn et al.[14] for 1990, inflated at 3% per year (or $20 million), is very similar to the estimate we have reached in this study. Their study used a more macro approach, taking the proportion of total Canadian hospital days accounted for by patients with asthma and multiplying this by the aggregate cost data for all Canadian public hospitals. Our research study involved a micro approach, using the Quebec Ministry of Health and Social Services reported cost and length of stay by service and ward, in the majority of cases adjusted specifically for the ward in which the patient was treated. Nonetheless, the current study may have left some asthma hospitalization costs unaccounted for, as we reviewed only short-term hospital centres and only hospitalizations for a period of 30 days or less. However, those hospitalizations not included accounted for less than 1% of the total asthma hospitalizations for 1994/95.

Conclusion

This study shows similar overall rates of hospitalization in 1988/89 and 1994/95, but with an important rise in the rates among very young children. There were decreases in rates in very few age groups. A small decrease in mean length of stay was seen.

Many of the trends and variations in asthma hospital use found in this study have been seen previously and their causes discussed. Certainly, in analyses of institutional database information it is difficult to determine the causes of changing patterns of use. However, even if the increases in rates of hospitalization seen in very young children could be attributed in part to a change in physician practice or an increase in the use of asthma diagnosis, the rate has doubled since the beginning of the decade and should signal an alarm that justifies further investigation.

A one-year cost of $18–21 million may seem high for asthma hospital costs, but it is most likely a considerable underestimation of the true hospital cost because emergency department visits and physician costs were not included in the analysis.

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APPENDIX

Example of the calculation of the NIRRU and adjustment for length of stay (LOS)

$NIRRU_Q = NIRRU_M + (NET\ LOS_{Q\text{-}M} \times NIRRU_M \div LOS_M \times Ratio_{FC})$

where

$NIRRU_Q$ = Quebec cost index for the APR-DRG
$NIRRU_M$ = Maryland cost index for the APR-DRG
$NET\ LOS_{Q\text{-}M}$ = Difference between Quebec and Maryland of average length of stay for the APR-DRG
LOS_M = Average length of stay for the APR-DRG in Maryland
$Ratio_{FC}$ = Ratio of fixed daily costs to average daily costs for the APR-DRG in Maryland

To calculate the NIRRU for an APR-DRG that, in Maryland, was given an index of 2.5 per case, had an average stay of 5 days and a fixed-cost ratio of 60%,

$$NIRRU_Q = 2.5 + ((7\text{-}5) \times 2.5 \div 5 \times 0.6) = 3.1$$

The last step is to normalize all the DRGs thus calculated to ensure that the total of the weighted cases equals the real total.

This calculation is applied to all except the atypical cases. Atypical cases are long-stay patients occupying short-stay beds, patients who died, patients discharged without authorization, transfers, home-care patients, patients admitted and discharged the same day, and patients whose stay exceeded a certain maximum (calculated to exclude about 3% of cases). NIRRUs for atypical cases are calculated not on the basis of the average DRG but on their actual average stay in proportion to the average Quebec stay for their DRG. An additional adjustment is also made to the NIRRU for those who have died or been transferred according to the difference in the use of resources as a function of the date of death or transfer. **O**

The Cost of Suicide Mortality in New Brunswick, 1996

Dale Clayton and Alberto Barceló

Abstract

Suicide is a major public health problem in Canada. Suicide deaths affect society by consuming both human lives and economic resources. The present study estimates the economic impact of suicide deaths that occurred in New Brunswick in 1996, using the human capital approach. For the 94 suicide deaths reported, direct costs for health care services, autopsies, funerals and police investigations were $535,158.32. Indirect costs, which estimate the value of lost productivity due to premature death, had the largest economic value, of $79,353,354.56. The mean total cost estimate per suicide death in 1996 was $849,877.80. Although the most significant impact of a suicide death remains the loss of a human life, these results indicate that the economic cost of this public health tragedy in New Brunswick is also great. To our knowledge, this report provides the first complete cost-of-suicide analysis performed in a Canadian province.

Key words: *Canada; cost of illness; New Brunswick; suicide*

Introduction

Suicide touches the lives of many Canadians. In 1996, suicide was the leading cause of death among those aged 25**S**29 years in New Brunswick.[1] Previous studies have shown that suicide rates in New Brunswick increased from 1987 to 1995,[2] from 9.5 per 100,000 (95% confidence interval [CI] = 7.46**S**12.07) to 16.17 per 100,000 (95% CI = 13.48**S**19.36). Suicide deaths accounted for 1.4% of all deaths occurring in New Brunswick in 1987,[3] and this figure rose to 2.0% of all deaths in 1995,[4] although the increase was not statistically significant. This provincial ranking compares with national statistics in which suicide deaths remained at 1.9% of all deaths in both 1987[3] and 1995.[4] An awareness of rising suicide rates has led to questions about the economic impact of suicide in New Brunswick.

Although many Canadian cost-of-illness studies have been completed,[5**S**11] no Canadian cost-of-suicide studies have been reported that include both direct and indirect costs. Earlier Canadian cost-of-suicide studies have focused on only one category of costs (direct or indirect), but not both. Hanvelt et al. estimated the indirect cost per suicide death of men aged 25**S**64 in Canada from 1987 to 1991 at $516,800 (1990 US$).[11] Using the conversion rate to 1990 Canadian dollars cited by Hanvelt et al. of $1.167 (CAN) = $1 (US) and adjusting to 1996 Canadian dollars using the consumer price index,[12] the estimate by Hanvelt et al. becomes $684,524.86 per suicide death. Hanvelt et al. further reported that for men of this age group, suicide deaths resulted in the third greatest loss in productivity, behind HIV/AIDS deaths and motor vehicle fatalities.[11] Similarly, Miller estimated suicide deaths by gunshot in Canada in 1991 to cost $1,036,494 per suicide death (1993 CAN$);[6] this does not include Miller's estimate of lost quality of life. Adjusting to 1996 dollars, this estimate translates to $1,078,238.85 per suicide death.

Several US studies have examined the economic burden of suicide deaths in association with specific mental disorders[13**S**15] or within specific age groups.[16] Although these studies have been useful in quantifying the cost of suicide within these groups, the appropriateness of extrapolating from these studies to a broader Canadian population remains questionable. Issues that arise when making these US–Canadian comparisons include differences in health care costs, given the different health care systems in the two countries, and the socio-economic representativeness of suicides occurring within specific age or mental illness categories with respect to all suicides occurring in Canada. Table 1 summarizes the results of previous cost-of-illness studies as they relate to suicide deaths.

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TABLE 1

Previous cost-of-illness studies including data on suicide deaths

Author	Country	Year	Cost per suicide death	Comments
Stoudemire et al.[14]	US	1980	$260,691 (1980 US$)	Includes only discounted lifetime earnings
Hanvelt et al.[11]	Canada	1987 1991	$516,800 (1990 US$)	Includes only production losses for suicide deaths of males aged 25 64
Miller[6]	Canada	1991	$1,036,494 (1993 CAN$)	Does not include Miller s estimate of lost quality of life; based only on deaths by gunshot
Wyatt and Henter[15]	US	1991	$591,475 (1991 US$)	Includes indirect costs only
Palmer et al.[13]	US	1994	$397,066 (1994 US$)	Includes indirect and direct costs; incidence was estimated by applying 1991 rates to 1994 population

This study used an incidence-based human capital approach to estimate the total economic burden of suicide deaths in New Brunswick in 1996.

Methods

Identifying Completed Suicide Cases

Suicide deaths that occurred in New Brunswick in 1996 were identified from the New Brunswick Vital Statistics database. Name, address, Medicare number, date of birth and date of death were collected for each case, and each case was cross-referenced with the suicide database of the New Brunswick Coroner's Office to ensure that all reported suicide deaths in the province had been identified.

Cost Estimates

Costs were conceptually categorized into two groups: actual dollar expenditures related to the suicide death (direct costs) and estimates of the value of future productivity losses (indirect costs). It should be noted that this classification into direct and indirect categories is arbitrary and does not affect the resulting economic value estimates.

Direct Costs

Ambulance services

The use of ambulance services in association with each suicide case was determined by cross-referencing Medicare numbers with the New Brunswick Ambulance Services database. The average cost per ambulance service in 1996 was then applied to the identified cases. This cost was estimated by dividing the total cost of operating ambulance services in the province during the 1996/97 fiscal year by the number of service calls answered during that period.

Hospital services

The Hospital Financial Utilization Management System (HFUMS) of the Department of Health and Community Services was cross-referenced with Medicare numbers of completed suicide cases. Hospital services that were shown to be associated with a suicide attempt and subsequent death were included. For each case identified, the records department of the associated hospital was contacted and asked for the Resource Intensity Weight (RIW) assigned to each case by the Canadian Institute for Health Information.[17] Using the most recent dollar value equivalent (1994/95) calculated for HFUMS adjusted to 1996 values according to the consumer price index[18] (1 RIW = $2,829.62), actual cost estimates for each case were made by multiplying the RIW by the equivalent dollar value.

Physician services

Costs for physician services were identified by cross-referencing Medicare numbers of completed suicides cases with the New Brunswick Medicare payment database. Physician services provided one day before a successful suicide attempt and up to and including the day of death were included in our cost estimate.

Autopsy services

Data relating to costs of autopsy services were obtained directly from the New Brunswick Coroner's Office. These data reflected costs associated with performing a post-mortem examination but did not include such services as transporting the body to a regional morgue facility.

Funeral/cremation services

A provincial average cost for funeral and cremation services provided in 1996 was calculated from information obtained from all funeral/cremation service providers in the province. All service providers were asked to report the number of funeral/cremation services provided by their establishment in 1996 as well as the average cost for those services. A provincial average was then calculated by weighting the information supplied by each provider to the total number of services that were reported.

Police investigations

Costs incurred for the police investigation of suicide deaths in New Brunswick in 1996 were obtained directly from all police forces in the province. Each of the 16 regional police forces as well as the New Brunswick Division of the Royal Canadian Mounted Police were asked to supply the number of suicide cases investigated in their jurisdiction during the 1996 calendar year. Each police force provided estimates of the total cost incurred for their suicide investigations based on personnel costs.

Indirect Costs

Potential years of life lost (PYLL)

PYLL calculations provide a quantifiable estimate of the number of years of potential or productive life lost as a result of premature death. PYLL before age 75 were calculated and expressed as a ratio to the mean population under age 75 in 1996, as described by the Canadian Institute for Health Information.[19]

Discounted future earnings (DFE)

Lost future earnings as a result of suicide death were calculated using the model developed by Vodden et al. for the Ontario Ministry of Transportation.[10] The model estimates total future earnings lost as a result of premature death for both labour force work and unpaid labour (see Appendix). Future earnings were discounted by an appropriate rate to convert them to present day values. A rate of 4% was used for calculations based on recommendations made by Miller et al.[20] and the experiences of other cost-of-suicide reports.[13] All calculations of discounted future earnings were carried out using the S-Plus version 4.5 software package.[21]

Survival probabilities, $P_{y,s}(n)$, were collected from the New Brunswick Statistics Agency based on published reports from Statistics Canada.[22] Mean annual employment earnings by age and sex in New Brunswick, $Y_s(n)$, were obtained from the 1996 Statistics Canada Labour Force Survey.[23]

Information relating to the value of homemaking services was taken from the Statistics Canada publication *Households' Unpaid Work: Measurement and Valuation.*[24] Data drawn from this publication were based on the results of the 1992 national General Social Survey (GSS) using a generalist approach for estimating replacement costs (see reference for a detailed description of methodology). Replacement cost data by demographic group were converted to annual dollars per person using census population estimates.[24] The value of homemaking services by age and sex, $Y^h_s(n)$, was then entered into the DFE model similarly to mean annual employment earnings, $Y_s(n)$ (see Appendix).

Labour productivity data are reported annually by the Centre for the Study of Living Standards.[25] A rate of increase in labour productivity of 0.04 $GDP/hour/employed worker was estimated by calculating the mean of the three-year moving averages of the annual change in labour productivity from 1984 to 1995.

Results

Ninety-three suicide deaths were identified in both the Vital Statistics and Coroner's Office databases. One additional case was found in the Coroner's Office database that did not appear in the Vital Statistics data. Information from both sources was combined, and a total of 94 deaths was used in all calculations. Table 2 summarizes the total cost estimates associated with suicide deaths in New Brunswick in 1996. The total cost of suicide deaths was calculated to be $79,888,513.17.

TABLE 2

Costs associated with suicide deaths, by cost category, New Brunswick, 1996

Cost category	*n*	Cost	Calculation method
DIRECT COSTS			
Ambulance services	51	$38,130.00	Average
Hospital services	6	$35,130.87	Actual
Physician services	19	$4,393.67	Actual
Autopsy services	74	$26,000.00	Average
Funeral services	94	$380,358.78	Average
Police investigations	69	$51,145.00	Average
INDIRECT COSTS			
Discounted future earnings	94	$79,353,354.56	Estimate
TOTAL	94	$79,888,513.17	

Direct Costs

Ambulance services

Sixty-two ambulance services were provided to 51 suicide cases in 1996. Multiple services were provided to some cases for transfer between hospitals. The total cost for the year was calculated by applying the average cost per ambulance service call of $615 to the 62 cases ($615 x 62 cases = $38,130.00).

Hospital services

A search of the Hospital Services database identified six completed suicide cases in 1996 that had received hospital services as a result of the suicide. For each of these cases, RIW values ranged from 0.6430 to 4.0404. Applying dollar value equivalents to these RIW values resulted in a range of costs from $1,819.45 to $11,432.80. The total cost for hospital services for these six cases was $35,130.87.

Physician services

Physician services costs were included where payment for such services was made by New Brunswick Medicare. A search of the Medicare database found physician services paid for 19 of the 94 suicide cases. Six of these nineteen cases included physician services provided during a hospital stay. Payment for physician services by case ranged from $15.30 to $1,098.33, with a total cost of $4,393.67 for all cases in 1996.

Autopsy services

New Brunswick Coroner Services recorded 74 autopsies for suicide-related deaths that occurred in 1996. A total cost of $26,000.00 was reported for the provision of these services, at an average cost of $351.35 per suicide death.

Funeral/cremation services

Responses from individual funeral/cremation service providers recovered cost information on 3,507 services out of a total of 5,949 services provided in the province in 1996.[26] Based on this 59% of all services provided, an average cost of $4,046.37 was calculated. Applying this average cost to each of the 94 cases occurring in 1996 resulted in a total cost of $380,358.78.

Police investigations

All the 17 police forces in New Brunswick participated in the current study. A total of 69 investigations were reported across the province with costs ranging from $180 to $2,500 per case. A total of $51,145.00 was spent on police investigations of suicide deaths, with an average cost of $741.23 per case.

Indirect Costs

Potential years of life lost (PYLL)

Using an upper age limit of 75 years, potential years of life lost were calculated for all suicide cases occurring in 1996. Total PYLL by age and sex are shown in Table 3 as well as PYLL rates per 1,000 persons. The largest number of PYLL occurred among those aged 35 to 49. Total PYLL for men of this age group was 1,227 years and for women, 170 years. The second largest loss was seen among those aged 20 to 34 (852 and 148 years for men and women respectively).

Discounted future earnings

Total discounted future earnings were calculated for each case in 1996 using a discount rate of 4% (see Appendix). Estimated discounted future earnings for the 94 suicide deaths in 1996 were calculated to be $79,353,354.56, providing the largest contributing factor (99%) of the overall cost of suicide deaths. A sensitivity analysis of the 4% discount rate was performed to assess the variability of discounted future earnings at 2%, 4%, 6%, 8% and 10% discount rates. The results of this analysis are presented in Figure 1.

Method of Suicide

Since average costs were used in the estimation of ambulance, autopsy and funeral services, and police investigation costs were not available by suicide method, accurate comparison of total costs by suicide method is not possible. However, including only cost estimates for hospital and physician services provides a relative ranking of suicide method by health care costs (Table 4). Using this comparison, suicide by firearm was the most costly method ($13,920.32), followed by jump/fall ($12,531.13) and strangulation ($10,541.85).

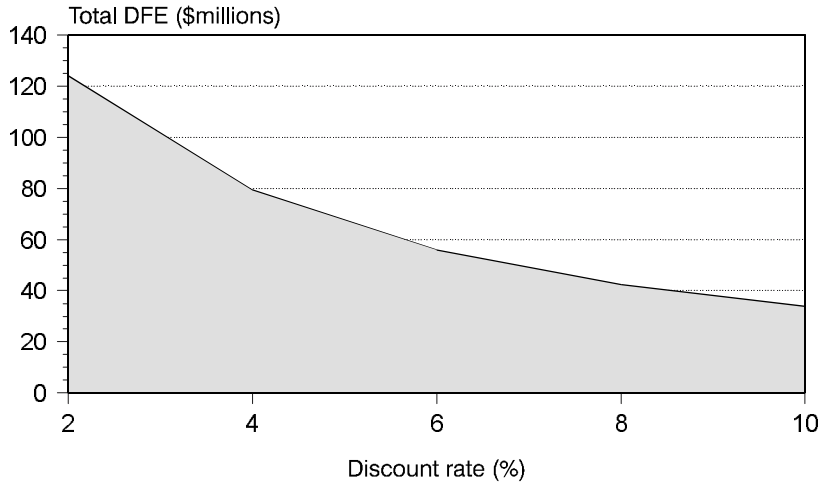
TABLE 3

Potential years of life lost (PYLL) due to suicide deaths, by age and sex, New Brunswick, 1996

Age group	Males		Females		BOTH SEXES	
	n	PYLL	*n*	PYLL	*n*	PYLL
0 9	0	0	0	0	0	0
10 19	5	299	2	119	7	418
20 34	18	852	3	148	21	1000
35 49	37	1227	6	170	43	1397
50 64	12	231	2	41	14	272
65+	8	24	1	8	9	32
TOTAL	80	2633	14	486	94	3119
Per 1000		7.21		1.34		4.29

FIGURE 1

Total discounted future earnings (DFE) by discount rate



The greatest cost of suicide deaths occurred in those age groups with the greatest number of suicide deaths. This was found to be the 35**S**49 age group for both men ($31,805,592.92; *n* = 37) and women ($4,418,836.70; *n* = 6) (Table 5). Of the 94 suicide deaths occurring in 1996, 85.1% were male, accounting for 84.4% of the total provincial cost of suicide.

Discussion

The results of the present study indicate that suicide deaths have a significant impact on the New Brunswick economy. Total average cost per suicide death in 1996 was estimated to be $849,877.80. The per capita cost of suicide deaths for the population of New Brunswick was $104.84. This does not include the emotional and psychological burden experienced by the friends and family members of suicide victims. Nor does it encompass the value of that part of a person's life that cannot be estimated simply by a loss in productivity (e.g. the value of being someone's friend, the value of being aware of one's existence, the value of emotional experiences, etc.).

This study made use of the human capital approach to estimate the value of lost productivity due to premature death. This approach estimates loss by approximating current market values for lost productivity in the future.[4,9,27] This estimate is made for both paid (e.g. employment) and unpaid labour (e.g. homemaking). Lost productivity can be quite easily summed using widely accepted numerical values; employment earnings by age and sex are easily reproducible and measurable numbers. Using a discounted future earnings model,[10] the age- and sex-specific values of both paid and unpaid labour can be summed over the years of life lost to premature death, and adjusted by labour productivity and discount rates.

Another method of approximating the value of life lost is the "willingness-to-pay" approach.[4,9,27] Unlike the human capital approach, which estimates the market value of human productivity, willingness-to-pay reflects the societal value of life by estimating the amount of money people would be willing to pay to avoid a suicide death. The willingness-to-pay approach is believed to assign a greater economic value to lost life than the human capital approach, as it encompasses the psychological and physical burden of pain, suffering and lost quality of life. The decision to use the human capital approach in this study was made on the basis of the availability of relevant data sources and the reproducibility of the study's results.

This study provides a reference point from which subsequent cost-of-suicide studies may be compared. These results are similar to those reported by Hanvelt et al.[11] and Miller,[6] given their focus on either partial cost or specific method. Indirect costs per suicide death of males aged 25**S**64 estimated by Hanvelt et al. were $684,524.86 (adjusted to 1996$). As expected, this was less than our estimate of both indirect and direct costs for both sexes and all age groups, of $849,877.80. Miller estimated total costs per suicide death by gunshot to be $1,078,238.85 (adjusted to 1996$). This does not include Miller's estimate of "lost quality of life", which was not included in the present study. Miller's estimate was greater than that for the gunshot suicides included in our study ($816,849.51 per death). This difference is likely due to estimates of discounted future earnings in the two studies. The age and sex of the cases sampled heavily influence discounted future earnings estimates. As may have occurred in Miller's study, a sample of younger cases with a higher proportion of males would result in a higher estimate.

TABLE 4

Hospital and physician service costs associated with suicide deaths, by method, New Brunswick, 1996

Suicide method[a] (ICD-9 code)	Hospital services *(n)*	Physician services *(n)*	TOTAL COST
Firearm (955.0 955.4)	$13,314.21 (2)	$606.11 (6)	$13,920.32
Jump/fall (957)	$11,432.80 (1)	$1,098.33 (1)	$12,531.13
Strangulation (953.0 953.9)	$8,564.41 (2)	$1,977.44 (8)	$10,541.85
Overdose (950.0 950.9)	$1,819.45 (1)	$711.79 (4)	$2,531.24
TOTAL	$35,130.87	$4,393.67	$39,524.54

TABLE 5

Total cost of suicide deaths, by age and sex, New Brunswick, 1996

Age group	Males		Females		BOTH SEXES	
	n	Cost	*n*	Cost	*n*	Cost
0 9	0		0		0	
10 19	5	$7,131,343.41	2	$2,877,343.60	7	$10,008,687.01
20 34	18	$22,528,517.82	3	$3,766,926.95	21	$26,295,444.77
35 49	37	$31,805,592.91	6	$4,418,836.70	43	$36,224,429.61
50 64	12	$4,814,204.44	2	$1,093,031.02	14	$5,907,235.46

This report provides an overall cost estimate of nearly $80 million for suicide deaths occurring in New Brunswick in 1996, which translates to an average cost of $849,877.80 per suicide death. With greater refinement of data sources, future studies should include the cost of mental health services for friends and family members of suicide victims and an estimation of lost productivity values for those grieving a suicide death.

It would also be possible to broaden the scope of future cost-of-suicide studies to include all forms of suicidal behaviour. This would include not only costs following a suicide death, but costs incurred for each suicidal person before their successful attempt. A further step would be to then include costs associated with suicide attempts that never result in suicide death. Such a study would provide a complete profile of the economic impact of suicidal behaviour in society. Nevertheless, the present study provides the groundwork for further research.

Summary

In summary, this report describes the costs associated with suicide deaths occurring in New Brunswick in 1996. The model used to assess these costs involved an incidence-based human capital approach involving both direct and indirect costs. A total cost of $79,888,513.17 was reported for the 94 suicide deaths in 1996, resulting in a mean cost of $849,877.80 per suicide death. An itemized breakdown of costs was presented by age, sex and method of suicide. Comparisons with other Canadian cost-of-fatal illness studies are discussed, and suggestions for further research are given.

Acknowledgements

The authors wish to thank Varsha Chhatre, biostatistician with the New Brunswick Provincial Epidemiology Service, for her technical assistance in the calculation of discounted future earnings.

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APPENDIX

Discounted future earnings model

$$DFE = \sum_{n=y}^{99} P_{y,s}(n)\,[Y_s(n)\,E_s(n) + Y^h{}_s(n)\;E^h{}_s(n)] \times \frac{(1+g)^{n-y}}{(1+r))^{n-y}}$$

where

DFE = discounted future earnings lost due to suicide death

$P_{y,s}(n)$ = probability that a person of age y and sex s will survive to age n

y = age at which the individual successfully completed suicide

s = sex of the individual

n = age of the individual

$Y_s(n)$ = mean annual earnings of an employed person of sex s and age n including the value of fringe benefits

$E_s(n)$ = proportion of the population of sex s and age n that are employed in the labour market

$Y^h{}_s(n)$ = mean annual imputed value of homemaking services of a person of sex s and age n

$E^h{}_s(n)$ = proportion of the population of sex s and age n that are keeping house

g = rate of increase of labour productivity

r = real discount rate

Source: Adapted, with permission, from Reference 10 **O**

Workshop Report

Canadian National Workshop on Measurement of Sun-related Behaviours

Chris Lovato, Jean Shoveller, Christina Mills and an Expert Panel

Introduction

Skin cancer has been described as an emerging epidemic in North America.[1–3] The National Cancer Institute of Canada estimates that 66,000 new cases of skin cancer will be diagnosed in 1999 in Canada.[4] Epidemiologic evidence suggests that cumulative exposure to sunlight is necessary for the development of squamous cell carcinoma, whereas intense sun exposure and sunburns received during childhood are more important in the development of melanoma and basal cell carcinoma of the skin.[5–9]

Sun exposure and protection are at least partly under the control of individuals. Therefore, it is important to pursue behavioural interventions as an essential component of a comprehensive set of skin cancer prevention strategies. In turn, monitoring sun-related behaviours is important in the development and evaluation of interventions as well as in surveillance of behavioural change across populations. One of the greatest challenges facing behavioural researchers in skin cancer prevention is the lack of comparability of measures across studies. The identification of a standard set of items would enhance the quality of research and program evaluation in Canada and contribute to similar efforts in other parts of the world.

The idea for the workshop described in this paper emerged from recommendations identified at the 1997 Workshop on Research, Policy and Program Planning on Sun Protective Behaviours.[10] At the 1997 workshop, participants developed a set of recommendations for research initiatives related to sun protection efforts in Canada. One of the primary recommendations was to develop a standard set of definitions and core items to assess sun-related behaviours. In response, Chris Lovato, Jean Shoveller and Christina Mills agreed to co-chair the 1998 Canadian National Workshop on Measurement of Sun-Related Behaviours. The purpose of this workshop was to develop consensus on a standard set of measures for program evaluation and for monitoring of sun exposure and protective behaviours in Canada.

Before the workshop took place, a systematic review of the published literature was conducted to collect reports and instruments previously used to measure sun-related behaviours. The search of electronic databases (e.g. MEDLINE, CancerLit) included peer-reviewed and non-peer-reviewed publications and was limited to English-language articles published between 1990 and 1998. In addition, the reference lists of each of the publications retrieved were scanned. Members of the workshop planning committee also recommended published reports and unpublished instruments for inclusion. Finally, scientists working in the field were asked for copies of instruments that had not been published previously. As a result, a total of 112 publications and instruments were identified.

Five background papers were commissioned, which synthesized and critically assessed the literature and available instruments in the areas of sun exposure, sunburn, protective behaviours, artificial tanning and phenotype. Each background paper provided recommendations regarding standardized operational definitions and core items that could be used in routine behavioural surveillance efforts and program evaluation. Participants were provided with the background papers before the workshop.

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Expert Panel: List of workshop participants at end of article

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Summary of Workshop Proceedings

The workshop was held on October 29–30, 1998, at the University of British Columbia. Invited participants (17 in total) included skin cancer researchers and representatives from Health Canada, Environment Canada, the Canadian Dermatology Association and the Canadian Association of Optometrists. A representative from the US Centers for Disease Control and Prevention was also invited to attend. Participants engaged in a series of small group discussions about the background papers and identified specific recommendations for operational definitions and core items. These recommendations focused on measurement issues related to sunburn, phenotype, sun exposure and protective behaviours. Participants also identified priorities for further research on measurement of sun-related behaviours. Two themes emerged over the two-day meeting: the unique characteristics of sun-related behaviours and the challenges associated with data collection and measurement.

Participants identified a number of factors that differentiate sun-related behaviours from other health behaviours (e.g. those related to nutrition, tobacco).

- In Canada, sun exposure is by and large a seasonal behaviour that varies geographically as a result of the large land mass and differences in weather patterns. Thus, a national study conducted over a broad geographic area that examines a specific exposure period requires measures sensitive to such external influences.
- Sun-related behaviours require individuals to interpret and respond to their risk according to a complex set of environmental and physiological cues.
- Comprehensive sun protection requires individuals to undertake a set of behaviours. Therefore, research must account for a *set* of behavioural outcomes rather than a single indicator.
- A number of non-behavioural factors influence individual risk, including phenotype, occupation and age.
- Some sun protection messages (e.g. avoid sun between 11 am and 4 pm) may conflict with health messages that promote participation in outdoor physical activities.
- There is a lack of definitive evidence regarding the effectiveness of sunscreen, although it is one of the primary methods of sun protection used by many people.

In discussing the background papers and the unique nature of sun-related behaviours, workshop participants also identified a number of points related to data collection and measurement.

- Most previous research has relied on self-reported behaviours by youth and adults and proxy reports for children. The limitations of self-report and proxy data should not be overlooked. Some recent studies have tried to incorporate objective data collection tools (e.g. daylight exposure monitors worn as wristwatches), which may serve as useful approaches to developing validated self-report measures.
- Operational definitions of sun-related variables have varied greatly across published studies. This was identified as a serious barrier to advancing this area of research.
- There is also considerable variation related to recall periods. For example, some studies assess general patterns of sun exposure and protection (e.g. over the entire summer), whereas others assess behaviours in specific, brief time periods (e.g. the previous weekend).
- More work is needed to develop scales and indices for assessment of sun-related behaviours. Most previous studies have reported on individual protective behaviours and have not considered the potential cumulative effect of multiple protective behaviours.

The workshop resulted in a set of recommendations that will be useful to those conducting research and program evaluations in this area. Overall, workshop participants identified measurement research as a high priority.

Recommendations

Core Items

Six core items were developed for inclusion in omnibus-style behaviour surveillance surveys and smaller scale evaluation efforts. Table 1 lists the recommended core items in order of priority—sunburn, phenotype, sun exposure and sun protection—and summarizes the rationale for each item. These core items are recommended for inclusion in population-based surveys, including the Canadian National Population Health Survey. The items were developed for use in personal interviews, telephone interviews or self-administered survey formats. They are suitable for wider dissemination within Canada and internationally to other researchers in skin cancer prevention.

TABLE 1

Recommended core items for measuring sun-related behaviours

Item	Comment
SQ1: A sunburn is any reddening or discomfort of your skin that lasts longer than 12 hours after exposure to the sun or other UV [ultraviolet] sources, such as tanning beds or sunlamps. In the past year, has any part of your body been sunburned? Yes/No *Universe: All respondents* **SQ2**: Did any of your sunburns involve blistering? Yes/No *Universe: Respondents who had a sunburn in previous year* **SQ3:** Did any of your sunburns involve pain or discomfort that lasted for more than one day? Yes/No *Universe: Respondents who had a sunburn in previous year*	**Sunburn** These three items have been chosen as the most important items to be asked in an omnibus survey because they measure sunburn and also provide indirect measures of sun exposure and protective behaviours. If there is limited space, this series of items should be used. Past year was identified as the time frame for reporting because sunburns are not of high frequency or routine events. Use of this term also allows for ease of administering the item during any time of the year.
SQ4: Would you say the untanned skin colour of your inner upper arm is ... Light (white, fair, ruddy) Medium (olive, light brown, medium brown) Dark (dark brown, black) *Universe: All respondents*	**Phenotype** Phenotype is one of the primary risk factors associated with skin cancer. This item allows for more precise interpretation of the data collected using the above sunburn items.
SQ5: During this past June through August, on a typical weekend or day off from work, approximately how much time did you spend in the sun between 11 am and 4 pm? <30 minutes per day 30 minutes to 1 hour per day 1 2 hours per day 2+ hours per day *Universe: All respondents*	**Sun exposure** Sun exposure is a risk factor associated with skin cancer. In Canada, peak UVB exposure from the sun occurs during June through August between the hours of 11 am and 4 pm.
SQ6: Think of the most recent weekend or day off from work when you spent 30 or more minutes in the sun. Did you ... Seek shade: Yes/No Wear a hat that shaded your face, ears and neck: Yes/No Wear a shirt with long sleeves: Yes/No Wear long pants or a long skirt: Yes/No Use sunscreen with SPF 15+ on all exposed skin: Yes/No *Universe: Respondents who spent 30+ minutes per day in the sun*	**Sun protection** To maximize the accuracy of recall, this item should be used only if the survey is administered between the beginning of June and the end of September. The Canadian Dermatology Association has identified these five actions to protect against skin damage during exposure to the sun for 30+ minutes. All five actions are endorsed in the consensus statement generated at the National Workshop on Public Education Messages for Reducing Health Risks from Ultraviolet Radiation.

Further Research

The recommended core items should be pilot tested to assess their validity and reliability. In general, validation studies of self-report items should be considered a priority—for example, studies to validate self-reported phenotype against objective measures of skin colour and self-reported sun exposure against the results of daylight exposure monitors. Scales and indices that provide a composite score representing exposure and protective behaviours should be developed and validated.

International Collaboration

To advance the quality of measurement of sun-related behaviours and expand knowledge in this area of ultraviolet radiation research, an international collaboration to develop consensus regarding operational definitions and core items should be undertaken. On the basis of the success of the 1998 Canadian National Workshop on Measurement of Sun-Related Behaviours, it is recommended that this approach be considered for an international meeting.

Discussion

As skin cancer continues to be a public health problem in North America, surveillance will be required to monitor the prevalence of sun-related behaviours at the population level. As communities continue to demand interventions to prevent skin cancer, there will be an increasing need to evaluate the efficacy of programs. The recommended core items here are based on the accumulated evidence currently available. There are limitations to these items, including the accuracy of self-reported data. Further, the items developed during the workshop focused on adolescent and adult populations. Since reduction of exposure to UVB during childhood is critical to reducing the risk of skin cancer, measures need to be developed for use with this age group (e.g. parental proxy reports). New strategies also need to be developed to collect data from children themselves. The core items focus on behaviour and do not attempt to assess attitudes or barriers; local program evaluations may need to include supplemental items to address these areas. Finally, the survey items have not been tested and will require further assessment.

The process used in this workshop was influenced by previous efforts to establish standardized measures for use in tobacco control research.[11] The background papers developed and disseminated to participants before the workshop facilitated a common understanding of the conceptual and methodologic issues. The workshop process could also be applied to other areas, such as measurement of nutrition and physical activity.

To advance the development of knowledge related to health behaviour change, more comparability across research studies is required in Canada as well as internationally. In organizing this workshop, we noted that although there is an established body of research in sun protection, it is extremely difficult to compare results across studies because of the wide variations in the way behaviours are measured. Common barriers to evaluating interventions are the availability of measures and standards of acceptability. The establishment and use of core items help to address both issues.

Progress is being made regarding implementation of the workshop recommendations. The core items presented in Table 1 are currently being considered for inclusion in the Canadian National Population Health Survey. The items have also been presented at the 1999 biennial meeting of the Canadian Society of Epidemiology and Biostatistics. A number of workshop participants are conducting research in the following areas: pilot testing the core items, validating self-reported exposure and skin colour, and constructing an index for sun exposure and protective behaviours. In addition, researchers are developing items for use in measuring parents' reports of their children's sun-related behaviours.

These recommended core items will be useful to researchers and program evaluators addressing sun-related behaviours. Researchers should continue to conduct measurement studies in order to improve the quality of surveillance and evaluation tools. Efforts are currently under way to promote international consensus regarding measurement.

Acknowledgements

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Book Review

Injury Prevention: An International Perspective Epidemiology, Surveillance, and Policy

By Peter Barss, Gordon S Smith, Susan P Baker and Dinesh Mohan
New York: Oxford University Press, 1998; xii + 375 pp; ISBN 0-19-511982-7; $85.50 (CAN)

This book is a valuable resource for those involved in injury surveillance and prevention. It is international in scope and explores injury issues not only of developed countries, but also from the perspective of less developed countries and of indigenous peoples around the world.

The ideas and data presented combined with discussion of complex causal factors will engage the interest of public health professionals and other experts involved in injury prevention. Yet the uncomplicated manner in which the data are presented and the flowing, easy-reading style will also make it useful for anyone who is interested in injury prevention.

The book offers international data for people of all ages, including both intentional and unintentional injuries. It is well organized, starting with an overview of the epidemiology of injury, profiling international data on overall injury mortality and morbidity, and then discussing important categories of injury such as traffic injuries, drownings, falls, burns, poisonings, occupational injuries, homicides and suicides. Also included are sections on the costs of injury, treatment and rehabilitation.

The authors have gathered an impressive selection of international injury data. They try to present the data by age group and sex for a range of developing countries from all parts of the world and include comparison data from a few developed countries. Unfortunately, Canadian data are not routinely reported in this way although Canadian examples are frequently used in discussion, particularly illustrations from aboriginal communities.

Not all of the data shown are current, many are more than a decade old. This situation reflects the unfortunate lack of sound international injury surveillance rather than any inadequacy in data collection for the book. The authors compare injury rates across countries and provide detailed interpretation of the data as well as insightful discussion of exposure to hazards, complex causal factors and approaches to prevention. The discussion reveals remarkable understanding and sensitivity to the diverse contributions of population structure, environment, culture, social factors and political situation in patterns of injury.

The book includes many useful tables, most of which provide injury data. However, graphs and figures are used sparingly and the only illustration is the photograph on the cover. The pages of text are presented with wide margins into which sidebars are strategically placed. These sidebars feature short summaries, specific examples and interesting quotations.

The following 1949 quotation from John E Gordon is given at the opening of the first chapter. I think it provides an excellent introduction to the book and might also have served as the conclusion.

> *The newer concept of prevention, as it developed, was applied almost wholly to disease, to the sick. The injured were largely forgotten...*

Overall rating:	Very good to Excellent
Strengths:	International perspective, good data from diverse sources and in-depth discussion and interpretation
Weaknesses:	Limited number of graphs, charts and illustrations
Audience:	International medical and public health professionals, government regulators and policy makers, and others interested or involved in injury surveillance and prevention

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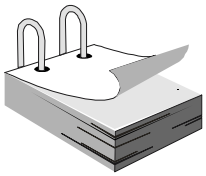

Calendar of Events

August 31 Sept 4, 1999 **Florence, Italy**	Epidemiology for Sustainable Health 15th International Scientific Meeting of the International Epidemiological Association	Organizing Secretariat IEA Florence 99 c/o SINEDRION Via G. Marconi, 27 50131 Firenze, Italy Tel: 39-55-570502 Fax: 39-55-575679 E-mail: iea99@stats.ds.unif.it <http://iea99ds.unifi.it>
October 1 3, 1999 **Ottawa, Ontario**	Building and Enriching Partnerships in the Management of COPD Conference presented by The Canadian Chronic Obstructive Pulmonary Disease (COPD) Alliance	The Canadian Lung Association National Office 508 1900 City Park Drive Gloucester, Ontario K1J 1A3 Tel: (613) 747-6776 Fax: (613) 747-7430 E-mail: cca@lung.ca <www.lung.ca/CCA/conference>
October 1 3, 1999 **Toronto, Ontario**	Closing the Loop: Evidence into Health Practice, Organization and Policy 3rd International Conference the Scientific Basis of Health Services Sponsors: Canadian Foundation for Health Services Research, Health Canada and Medical Research Council of Canada	3rd Intl Conference on the Scientific Basis of Health Services c/o Alysone Will, CMP The Paragon Conference & Event Group Inc. 704 205 Richmond Street West Toronto, Ontario M5V 1V3 Tel: (416) 979-1300 Fax: (416) 979-1819 E-mail: info@paragon-conferences.on.ca <www.paragon-conferences.on.ca/health99.html>
October 18 20, 1999 **Chilton, Oxfordshire** **United Kingdom**	International Workshop on UV Exposure, Measurement and Protection Sponsors: National Radiological Protection Board (NRPB), World Health Organization and International Commission on Non-Ionizing Radiation Protection	Dr Colin Driscoll NRPB (UV Workshop) Chilton, Didcot, OX11 0RQ United Kingdom Tel: 44-1235-822724 Fax: 44-1235-831600 E-mail: colin.driscoll@nrpb.org.uk <http://www.nrpb.org.uk/WHO-uv.htm>
November 11 13, 1999 **Halifax, Nova Scotia**	Fourth National Conference on Asthma and Education (ASED 4) Presented by the Canadian Network for Asthma Care (CNAC)	A Les McDonald Executive Director, CNAC 1607 6 Forest Laneway North York, Ontario M2N 5X9 Tel: (416) 224-9221 Fax: (416) 224-9220 E-mail: ased@cnac.net <www.cnac.net>

November 15 17, 1999 **Toronto, Ontario**	Celebrating Our Past, Building Our Future 50th Annual Ontario Public Health Association Conference Co-hosted by the Centre for Health Promotion and Toronto Public Health	OPHA Conference Secretary Toronto Public Health North York Civic Centre North York, Ontario M2N 5V7 Tel: (416) 395-7653 Fax: (416) 395-7691 <http://www.web.net/opha/>
November 30 Dec 2, 1999 **Dallas, Texas** **USA**	Prevention Successes 2000: Better Health for All 14th National Conference on Chronic Disease Prevention and Control Sponsors: Centers for Disease Control and Prevention, Association of State and Territorial Chronic Disease Program Directors and American Heart Association	Estella Lazenby The KEVRIC Company, Inc. 610 8401 Colesville Road Silver Spring, MD USA 20910 Tel: (301) 588-6000 Fax: (301) 588-2106 E-mail: elazenby@kevric.com <www.cdc.gov/nccdphp>
March 13 16, 2000 **Quebec City, Quebec**	Health and the Quality of Life: Our Municipalities in an Era of Globalization 3rd Conference of Local Health Authorities of the Americas Organized by *l Institut national de santé publique du Québec* and the WHO Collaborating Centre for the Development of Healthy Cities and Villages	Secrétariat du 3e Congrès des responsables locaux de santé des Amériques 938, rue Saint-Maurice Montréal (Québec) H3C 1L7 Tel: (514) 395-1808 Fax: (514) 395-1801 E-mail: 3econgres@opus3.com <http://www.msss.gouv.qc.ca/congres_quebec>
May 7 10, 2000 **Victoria, British Columbia**	Science and Policy in Action First International Conference on Women, Heart Disease and Stroke Heart and Stroke Foundation, American Heart Association, Health Canada and Centers for Disease Control and Prevention are providing early leadership	Taylor & Associates 18 5370 Canotek Road Gloucester, Ontario K1J 9E8 Tel: (613) 747-0262 Fax: (613) 745-1846 E-mail: gtaylor@netrover.com
May 28 30, 2000 **Ottawa, Ontario**	Charting the Course for Literacy and Health in the New Millennium First Canadian Conference on Literacy and Health Organized by the Canadian Public Health Association s (CPHA) National Literacy and Health Program	CPHA Conference Department 400 1565 Carling Avenue Ottawa, Ontario K1Z 8R1 Tel: (613) 725-3769 Fax: (613) 725-9826 E-mail: conferences@cpha.ca <www.nald.ca/nlhp.htm>
August 23 27, 2000 **Victoria, British Columbia**	ITCH 2000: From Potential to Practice International Conference on Information Technology in Community Health Call for abstracts and student poster contest deadline: **December 15, 1999**	ITCH 2000 c/o School of Health Information Science University of Victoria PO Box 3050, STN CSC Victoria, BC V8W 3P5 Tel: (250) 721-8576 Fax: (250) 472-4751 E-mail: itch@hsd.uvic.ca <http://itch.uvic.ca>

More 1998 Peer Reviewers

Our list of people to thank for doing peer review for us in 1998 (published in Volume 20, No 1) should have included two more names.

Gail Eyssen
Ken Johnson

Announcement

New journal now available

Cancer Strategy

ISSN: 1464-1828 / Quarterly

Editor-in-Chief: Karol Sikora, Chief, Cancer Programme, World Health Organization, International Agency for Research on Cancer

Free online sample copy available at <http://www.stockton-press.co.uk/cs>

CDIC: Information for Authors

Chronic Diseases in Canada (CDIC) is a peer-reviewed scientific journal published four times a year. Contributions are welcomed from outside of Health Canada as well as from within this federal department. The journal's focus is the prevention and control of non-communicable diseases and injuries in Canada. This may include research from such fields as epidemiology, public/community health, biostatistics, behavioural sciences and health services. CDIC endeavours to foster communication among public health practitioners, chronic disease epidemiologists and researchers, health policy planners and health educators. Submissions are selected based on scientific quality, public health relevance, clarity, conciseness and technical accuracy. Although CDIC is a Health Canada publication, authors retain responsibility for the contents of their papers, and opinions expressed are not necessarily those of the CDIC Editorial Committee or of Health Canada.

Feature Articles

Most feature articles are limited to 3500 words of text in the form of original research, surveillance reports, meta-analyses, methodological papers or literature reviews. The maximum length for Short Reports is 1500 words, and Position Papers should not exceed 3000 words.

Under normal circumstances, two other types of feature articles (both 3000 words maximum) will be considered as submissions only from authors within Health Canada: Status Reports describing ongoing national programs, studies or information systems of interest to chronic disease researchers and public health practitioners; and Workshop/Conference Reports of relevant workshops, etc. organized or sponsored by Health Canada.

Authors outside of Health Canada may submit reports for our Cross-country Forum (3000 words maximum) to exchange information and insights about the prevention and control of chronic diseases and injuries from research or surveillance findings, programs under development or program evaluations.

Additional Article Types

Letters to the Editor (500 words maximum) commenting on articles recently published in CDIC will be considered for publication. Book/Software Reviews (1300 words maximum) are usually solicited by the editors. In addition, the editors occasionally solicit Guest Editorials.

Submitting Manuscripts

Submit manuscripts to the Editor-in-Chief, *Chronic Diseases in Canada*, Laboratory Centre for Disease Control, Health Canada, Tunney's Pasture, CDIC Address Locator: 0602C3, Ottawa, Ontario K1A 0L2.

Since *Chronic Diseases in Canada* adheres in general (section on illustrations not applicable) to the **"Uniform Requirements for Manuscripts Submitted to Biomedical Journals"** as approved by the International Committee of Medical Journal Editors, authors should refer to the *Canadian Medical Association Journal* 1997 Jan 15; 156(2): 270–7 for complete details (or at **www.cma.ca/publications/mwc/uniform.htm**).

Each submission must have a covering letter signed by all authors that identifies the corresponding author (including fax number) and states that all authors have seen and approved the final manuscript and have met the authorship criteria of the Uniform Requirements. The covering letter should also include a full statement regarding any prior or duplicate publication or submission for publication. Written permission from anyone mentioned by name in the acknowledgements should appear at this time. Suggestions for appropriate peer reviewers are appreciated as well.

Manuscripts may be submitted in either English or French and will be published in both languages, if accepted. Submit four complete printed copies of a manuscript, double-spaced, on standard-sized paper with one-inch margins. Each section (i.e. title page, abstract and key words, text, acknowledgements, references, tables and figures) should begin on a separate, numbered page.

If a manuscript is accepted for publication, send the final hardcopy version with the accompanying text file in WordPerfect or ASCII, in IBM-compatible format, specifying the software version.

Abstract and Key Words

An ***unstructured*** abstract not exceeding 150 words (100 words only for Short Reports) must accompany each manuscript with three to eight key words noted below, preferably from the Medical Subject Headings (MeSH) of *Index Medicus*.

Tables and Figures

Tables and figures should be as self-explanatory and succinct as possible. They should not simply duplicate the text, but should illuminate and supplement it, and they should not be too numerous. Place them on separate pages after the references, numbered in the order that they are mentioned in the text.

Provide explanatory material for tables in footnotes, identifying the table footnotes by lower-case superscript letters in alphabetical order.

Figures must be limited to graphs or flow charts/templates; we are unable to publish photographic illustrations at this time. Specify the software used (preferably Harvard Graphics) and supply raw data (in hardcopy form) for all graphs. ***Do not import figures into the text of the manuscript.***

Authors must obtain written permission from the copyright holder to reproduce or adapt any tables or figures that have been published previously.

References

References should follow the Vancouver style, numbered consecutively in the order that they first appear in the text (identified by numbers in superscript or within parentheses) and arranged numerically in the reference list. References cited only in tables or figures should be numbered as above according to the first mention of the particular table/figure in the text. ***Remove any endnote/footnote word-processing feature used to generate a reference list.***

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