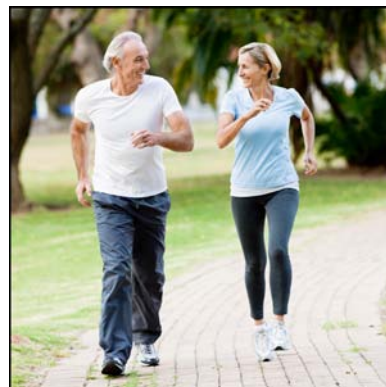


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- ... not applicable
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- r revised
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Canadian trends in cancer prevalence

by Larry F. Ellison and Kathryn Wilkins

Abstract

Background

Cancer prevalence trends are rarely reported in the published literature, and until now, have not been reported for Canada.

Data and methods

Based on incidence data from the Canadian Cancer Registry linked with mortality data from the Canadian Vital Statistics Death Database, trends in prevalence proportions over time were calculated by time since diagnosis for a large number of the most common cancers.

Results

Statistically significant increases in prevalence proportions were observed for most individual cancers, and most prevalence durations studied. Aging of the population contributed to these increases. Relatively large increases were observed for liver and thyroid cancer, while decreases occurred for cancers of the larynx and cervix uteri.

Interpretation

Information on how and why trends vary by cancer can inform resource allocation planning.

Key words

Epidemiologic methods, neoplasms, registries, surveillance

Authors

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The measure of prevalence, which is used to study the burden of a disease in a population, is a cornerstone of cancer surveillance. Duration-specific prevalence estimates, which incorporate the time elapsed since diagnosis, can be used as a proxy for specific care needs. This is because the length of time since detection of the cancer closely relates to the phase reached along the care continuum. Cases diagnosed in the previous ten years represent the major demand for health care services. In the first two years, services would likely include primary treatment and supportive care for recovery from its effects, followed over the next three years by close clinical assessment for recurrence, and then less intense follow-up over the next five years.^{1,2} Cancer-specific estimates are useful in health care planning, as cancer survivors' requirements for services vary according to the particular cancer involved.

Trends in cancer prevalence proportions reveal the dynamics of increase, decrease, or stability of cancers in the population, and thus, can be used in planning the allocation of diagnostic, treatment and care resources.^{1,3} Prevalence trends also provide information fundamental to making projections.

In Canada, the rate at which new cancer cases are diagnosed continues to rise,⁴ and survival is also increasing.⁵⁻⁷ A recent study provided a detailed report of cancer prevalence in Canada as of January 1, 2005.⁸ However, cancer prevalence trends are rarely published, and until now, have not been reported for Canada.

This report presents trends in two-, five- and ten-year cancer prevalence proportions for all cancers combined, and for more than two dozen of the most frequently occurring individual cancers. Age-adjustment was carried out to assess the contribution of population aging to changes in prevalence proportions. For the most common cancers, the data are examined by age group.

Methods

Data sources

Cancer incidence data are from the January 2011 version of the Canadian Cancer Registry (CCR), a dynamic, person-oriented, population-based database maintained by Statistics Canada. The CCR contains information on cases diagnosed from 1992 onward, compiled from reports from every provincial/territorial cancer registry. Mortality data are from the Canadian Vital Statistics Death Database, also maintained by Statistics Canada. The death data are based on information provided by the vital statistics registrars in each province and territory. Population estimates are from Statistics Canada's Demographic Estimates Compendium 2010.⁹

Analytical techniques

A file containing records of invasive cancer cases and *in situ* bladder cancer cases (the latter are reported for each province/territory except Ontario) was created using the multiple primary coding rules of the International Agency for Research on Cancer.¹⁰ Cancer cases were defined based on the *International Classification of Diseases for Oncology, Third Edition*¹¹ and classified using Surveillance, Epidemiology, and End Results (SEER) Program grouping definitions, with mesothelioma and Kaposi's sarcoma as separate groups.¹²

Mortality follow-up through December 31, 2007 was carried out by record linkage to the Canadian Vital Statistics Death Database (excluding deaths registered in the province of Quebec), and from information reported by the provincial/territorial cancer registries. For deaths reported by a

provincial registry but not confirmed by the national record linkage, the date of death was assumed to be that submitted by the reporting registry. When death was known to have occurred, but the date of death was completely missing (0.02% of deaths), the death was assumed to have occurred after December 31, 2007.

Tumour-based prevalence was determined directly, using the counting method.^{13,14} All first or subsequent primary invasive cancers and *in situ* bladder cases that were diagnosed in the time-frame under consideration among persons alive on a given index date were counted. For example, two-year prevalence for 2008 was estimated by counting the number of cancers diagnosed from January 1, 2006 to December 31, 2007 among persons still alive on January 1, 2008. Similarly, five- and ten-year prevalence estimates for 2008 were based on cases diagnosed from 2003 and 1998, respectively.

Because of issues with correctly ascertaining the vital status of cases diagnosed in Quebec, prevalence proportions do not include data from that province.

Crude prevalence proportions (per 100,000) were calculated by dividing prevalence counts by the population on the index date and multiplying by 100,000. Because published population figures represent mid-year estimates, the population estimates for each index date were derived by averaging population estimates for six months before and after the date. Age-standardized proportions were calculated by the direct method using the final post-censal estimates of the July 1, 1991 Canadian population, adjusted for census under-coverage, as the standard.¹⁵

Trends in prevalence proportions over time were determined using the Joinpoint Regression Program (v 3.4.3) distributed by the SEER program of the National Cancer Institute in the United States.¹⁶ A statistical algorithm finds the optimal number and location of places where a trend changes. The point (in time) where a trend changes is called a joinpoint. The (prevalence) rates are assumed to grow or decay exponentially (that is, to change

by a constant percentage each year). Thus, the slope in each segment can be associated with a fixed annual percent change (APC).

In the current study, all Joinpoint default settings were used, except that the maximum number of joinpoints was set at one for two- and five-year analyses, and at zero for ten-year analyses. When the program detected a statistically significant change in trend, the average annual percent change (AAPC) was also reported to provide a summary measure for the entire interval. It is estimated as a weighted average of the joinpoint APCs, with the weights equal to the lengths of each segment over the pre-specified fixed interval. When no change in trend is detected, the APC and AAPC statistics will yield identical values. The software indicates whether an AAPC is significantly different from zero at the level of $\alpha=0.05$ only, but provides p-values for the corresponding test involving the APC.

Results

Differences by cancer type

The proportions of prevalent cancer cases in the Canadian population increased significantly over the time periods considered. The two-year prevalence proportion for all cancers combined rose at an annual rate of 2.0% from 1997 to 2008, after holding steady from 1994 to 1997 (Table 1). Similarly, the five-year prevalence proportion rose by 2.1% per year from 1997 to 2008, and the ten-year proportion, by 2.4% per year from 2002 to 2008.

Statistically significant increases in prevalence proportions were observed for most individual cancers and prevalence durations. APC and AAPC values (where joinpoints were deemed appropriate) generally ranged from approximately 0.5% to 4%, though much higher rates were observed for liver and thyroid cancer.

Increases in prevalence proportions for liver and thyroid cancer were more than double those of any other cancer (Table 1, Figure 1). For liver cancer, the increase was greatest (8.5%) for ten-year

Table 1

Two-, five- and ten-year cancer prevalence proportion trends, by sex and cancer type, Canada excluding Quebec, 1994 to 2008

Sex/Cancer type	Two-year (1994 to 2008)		Five-year (1997 to 2008)		Ten-year (2002 to 2008)
	APC / Trend change year / APC	AAPC	APC / Trend change year / APC	AAPC	APC
Both sexes					
All cancers	-0.2 / 1997 / 2.0**	1.5*	2.1**	...	2.4**
Oral cavity & pharynx	-2.3** / 1999 / 0.9**	-0.3	-1.9* / 2000 / 0.8**	0.1	0.9**
Esophagus	2.1**	...	2.4**	...	3.3**
Stomach	0.1	...	0.0 / 2004 / 1.8**	0.6*	1.2**
Colorectal	1.7**	...	2.5** / 2003 / 1.9**	2.3*	2.4**
Colon excluding rectum	1.5**	...	1.9**	...	2.0**
Rectum and rectosigmoid	0.1 / 1997 / 2.5**	2.0*	3.2** / 2006 / 1.4	2.8*	3.1**
Anus	6.4** / 2001 / 0.9	3.6*	6.3** / 2002 / 1.8**	3.8*	3.2**
Liver	7.7**	...	8.3**	...	8.5**
Pancreas	2.7** / 2005 / 5.5**	3.3*	3.6**	...	4.0**
Larynx	-1.9**	...	-2.6** / 2004 / -0.8	-1.9*	-1.6**
Lung and bronchus	0.5** / 2004 / 2.5**	1.1*	0.9** / 2005 / 2.6**	1.3*	1.6**
Soft tissue	1.5** / 2003 / 5.7**	3.0*	1.8** / 2004 / 5.2**	3.0*	3.7**
Skin melanoma	2.7**	...	2.7**	...	2.7**
Breast	1.7** / 2000 / 0.6*	1.0*	2.3** / 2001 / 0.7**	1.3*	1.5**
Cervix uteri ¹	-1.6**	...	-1.5**	...	-1.3**
Corpus uteri ¹	-1.5 / 1996 / 2.0**	1.5*	1.7** / 2006 / 2.9**	1.9*	2.1**
Ovary ¹	-0.3 / 1998 / 1.5**	1.0*	0.9* / 2001 / 2.1**	1.7*	1.8**
Prostate ¹	-3.0 / 1997 / 2.9**	1.6*	3.0**	...	3.4**
Testis ¹	0.5**	...	0.6**	...	0.5**
Bladder (including in situ)	0.4**	...	0.3**	...	0.5**
Kidney & renal pelvis	2.1** / 2006 / 8.0**	3.0*	2.5** / 2006 / 4.8**	2.9*	3.1**
Brain	1.0**	...	0.6**	...	0.6**
Thyroid	3.9* / 1999 / 9.3**	7.4*	3.7 / 2000 / 9.5**	7.9*	8.4**
Hodgkin lymphoma	0.0	...	-0.4 / 2002 / 0.5*	0.1	0.2*
Non-Hodgkin lymphoma	2.7**	...	3.2**	...	3.8**
Multiple myeloma	2.6**	...	3.6**	...	4.0**
Leukemias	1.6** / 2002 / 3.9**	2.6*	1.9** / 2002 / 4.1**	3.1*	3.9**
Men					
All cancers	-1.3 / 1997 / 2.2**	1.4*	1.1 / 1999 / 2.5**	2.2*	2.7**
Oral cavity and pharynx	-2.2** / 2000 / 0.8*	-0.5	-1.1** / 2003 / 1.3**	0.0	0.6*
Esophagus	2.8**	...	3.3**	...	4.1**
Stomach	0.3	...	0.9**	...	1.6**
Colorectal	0.2 / 1997 / 2.2**	1.8*	2.5**	...	2.6**
Colon excluding rectum	1.7**	...	2.1**	...	2.2**
Rectum and rectosigmoid	-0.2 / 1997 / 2.8**	2.2*	3.5** / 2005 / 2.2**	3.1*	3.3**
Anus	8.0** / 2001 / -0.8	3.5*	8.6** / 2001 / 1.4**	4.0*	2.9**
Liver	8.4**	...	9.1**	...	9.0**
Pancreas	2.5** / 2005 / 7.2**	3.5*	3.2** / 2006 / 7.8*	4.0*	4.0**
Larynx	-2.0**	...	-2.6** / 2004 / -0.7	-1.9*	-1.6**
Lung and bronchus	-1.1** / 2004 / 1.3*	-0.4*	-0.8** / 2005 / 1.2**	-0.3*	0.0
Soft tissue	1.3** / 2003 / 6.6**	3.2*	1.3** / 2003 / 5.5**	3.2*	4.1**
Skin melanoma	3.0**	...	3.1**	...	3.0**
Breast	4.3** / 2005 / -3.3	2.6*	8.9** / 2000 / 2.2**	4.0*	3.3**
Prostate	-3.0 / 1997 / 2.9**	1.6*	3.0**	...	3.4**
Testis	0.5**	...	0.6**	...	0.6**
Bladder (including in situ)	0.4**	...	0.0 / 2003 / 0.8**	0.4*	0.5**
Kidney and renal pelvis	1.9** / 2005 / 6.6**	2.9*	2.3** / 2005 / 4.4**	2.9*	3.3**
Brain	1.1**	...	0.6**	...	0.7**
Thyroid	7.0**	...	4.1** / 2000 / 7.8**	6.8*	7.3**
Hodgkin lymphoma	-0.2	...	0.1	...	0.0
Non-Hodgkin lymphoma	3.0**	...	3.6**	...	4.4**
Multiple myeloma	2.9**	...	4.1**	...	4.7**
Leukemias	0.1 / 1998 / 3.3**	2.3*	2.1** / 2002 / 4.2**	3.2*	4.0**
Women					
All cancers	1.7**	...	1.9**	...	2.2**
Oral cavity and pharynx	-3.3 / 1997 / 1.2**	0.2	-2.0 / 1999 / 1.4**	0.7	1.4**
Esophagus	0.2	...	-1.1* / 2005 / 4.8*	0.5	1.2**
Stomach	-0.2	...	-1.0* / 2004 / 1.8*	0.0	0.6
Colorectal	1.5**	...	2.3** / 2003 / 1.5**	2.0*	2.1**
Colon excluding rectum	1.3**	...	2.2** / 2002 / 1.4**	1.8*	1.9**
Rectum and rectosigmoid	1.9**	...	2.8** / 2006 / 1.0	2.4*	2.7**
Anus	3.6**	...	5.6** / 2002 / 2.5**	3.9*	3.3**
Liver	4.1** / 2004 / 10.7**	5.9*	6.1**	...	7.0**
Pancreas	3.0**	...	3.4**	...	3.9**
Larynx	-1.8**	...	-2.1**	...	-1.7**
Lung and bronchus	2.5** / 2005 / 4.0**	2.8*	2.8** / 2005 / 3.8**	3.0*	3.3**
Soft tissue	1.8** / 2004 / 5.3*	2.8*	1.9** / 2005 / 4.9**	2.7*	3.3**
Skin melanoma	2.5**	...	2.3**	...	2.4**
Breast	1.7** / 2000 / 0.6*	1.0*	2.3** / 2001 / 0.7**	1.2*	1.5**
Cervix uteri	-1.6**	...	-1.5**	...	-1.3**
Corpus uteri	-1.5 / 1996 / 2.0**	1.5*	1.7** / 2006 / 2.9**	1.9*	2.1**
Ovary	-0.3 / 1998 / 1.5**	1.0*	0.9* / 2001 / 2.1**	1.7*	1.8**
Bladder (including in situ)	0.4*	...	1.9 / 1999 / 0.0	0.3	0.2*
Kidney and renal pelvis	2.2** / 2006 / 7.1*	2.9*	2.9**	...	2.9**
Brain	0.8**	...	0.6**	...	0.5
Thyroid	2.5 / 1998 / 9.5**	7.4*	3.6 / 2000 / 10.0**	8.2*	8.7**
Hodgkin lymphoma	0.2	...	-0.7 / 2003 / 1.2*	0.2	0.4**
Non-Hodgkin lymphoma	2.4**	...	2.7**	...	3.3**
Multiple myeloma	2.2**	...	2.9**	...	3.1**
Leukemias	1.6** / 2003 / 4.3**	2.6*	2.2** / 2004 / 4.6**	3.1*	3.7**

APC = annual percent change; AAPC = average annual percent change; when no change in trend is detected, the APC and AAPC are identical

¹ sex-specific population data used to derive prevalence proportions underlying trend analysis

* statistically significant (p < 0.05)

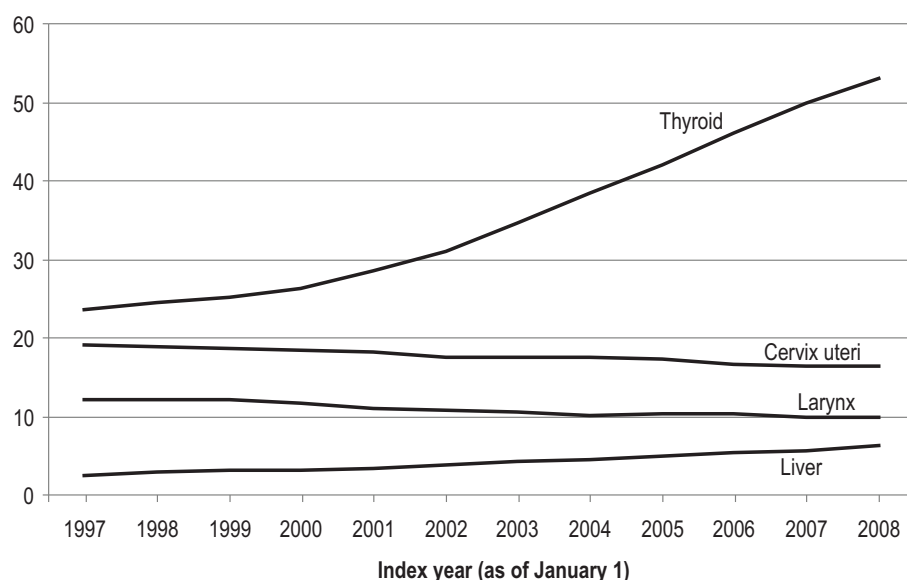
** statistically significant (p < 0.01) (applicable only for APC)

... not applicable

Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

Figure 1

Five-year prevalence proportions (per 100,000) of selected cancers, Canada excluding Quebec, 1997 to 2008



Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

duration. For thyroid cancer, increases in the proportions of two- and five-year prevalence exceeded 9% per year from 1999/2000 to 2008. Two- and five-year prevalence proportions for cancer of the anus also rose substantially until the early 2000s (more than 6% per year). Recent rates of increase were also high for the two-year prevalence proportions of pancreatic, and kidney and renal pelvis cancer, as well as for the five-year prevalence proportions of soft tissue, and kidney and renal pelvis cancer.

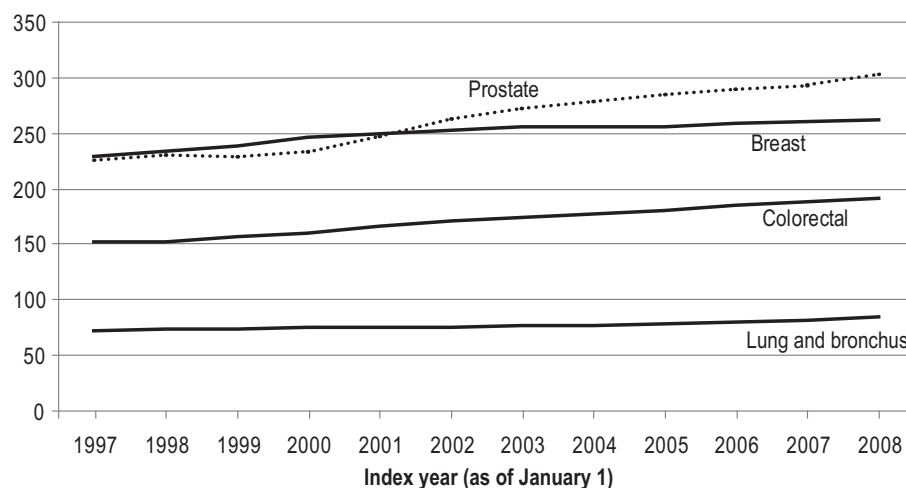
Among the cancers considered in this study, overall average annual decreases in prevalence proportions occurred only for cancers of the larynx and cervix uteri (Table 1, Figure 1). Annual rates of decrease for laryngeal cancer ranged from 1.6% (ten-year) to 1.9% (two- and five-year); however, the decline in five-year prevalence had been far more pronounced from 1997 to 2004 (2.6% per year) than from 2004 to 2008 (0.8%). Annual rates of decrease in cervical cancer prevalence proportions were fairly uniform across the three durations, at about 1.5%.

No overall statistically significant changes were observed for the two-

or five-year prevalence of Hodgkin lymphoma, or for the two-year prevalence of stomach cancer. For the two- and five-year prevalence of oral cavity and pharyngeal cancer, annual decreases of about 2% until 1999/2000, followed by increases of just under 1%, resulted in a nil average change.

Figure 2

Five-year prevalence proportions (per 100,000) of most commonly diagnosed cancers, Canada excluding Quebec, 1997 to 2008



Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

Leading cancers

The prevalence proportions of prostate cancer, the most common cancer in Canada on January 1, 2008 (Appendix Table A), rose substantially (Table 1, Figure 2). The five- and ten-year prevalence proportions increased by 3.0% and 3.4% per year, respectively; the two-year proportion increased more slowly, at an AAPC of 1.6%, tempered by a non-significant 3.0% per year decrease from 1994 to 1997.

Rates of increase in the prevalence proportions of breast cancer, the second most common cancer and the most common in women (Appendix Table A), were more moderate (Table 1, Figure 2). AAPCs ranged from 1.0% (two-year) to 1.5% (ten-year). Annual rates of increase in two- and five-year breast cancer prevalence proportions had been about three times as high before 2000/2001 as afterward.

Colorectal, and lung and bronchial cancer were the third and fourth most common cancers at the start of 2008. AAPCs in colorectal cancer prevalence proportions ranged from 1.7% (two-year) to 2.4% (ten-year) (Table 1, Figure 2). For lung and bronchial cancer, two- and five-year prevalence increased at a much higher annual rate (about 2.5%)

beginning in 2004/2005 than previously (less than 1% per year); the ten-year prevalence proportion increased by 1.6% per year from 2002 to 2008 (Table 1, Figure 2).

Differences by sex

Trends in prevalence proportions differed between men and women for a number of cancers (Table 1). The greatest disparity was for cancer of the lung and bronchus; for example, the five-year prevalence proportion

increased by an annual average of 3.0% in women, but decreased by 0.3% in men. Trends also differed between the sexes for esophageal cancer, although the discrepancies were smaller (slightly less than three percentage points). However, for esophageal cancer, rates of increase were higher in men than in women. For liver cancer, the annual rate of increase was relatively high in women (6.1%, five-year duration), but even greater in men (9.1%, five-year duration). By contrast, increases in thyroid cancer

prevalence proportions were higher for women than for men (8.2% versus 6.8%, five-year duration).

Differences by age

For all cancers combined, average annual age-specific rates of increase in prevalence proportions were generally about 1% per year among people younger than 80 (Table 2). There was little or no change in prevalence proportions among those aged 80 or older.

Table 2

Two-, five- and ten-year age-specific cancer prevalence proportion trends, all cancers combined and four leading cancers, Canada excluding Quebec, 1994 to 2008

Cancer type/Age group	Two-year (1994 to 2008)		Five-year (1997 to 2008)		Ten-year (2002 to 2008)
	APC / Trend change year / APC	AAPC	APC / Trend change year / APC	AAPC	APC
All cancers					
20 to 39	0.5** / 2002 / 1.4**	0.9*	0.3* / 2002 / 1.5**	0.9*	1.2**
40 to 49	-0.4 / 1998 / 1.3**	0.8*	1.0** / 2004 / 2.1**	1.4*	1.6**
50 to 59	1.0**	...	1.6** / 2004 / 1.1**	1.4*	1.3**
60 to 69	0.7**	...	1.7** / 2003 / 0.6**	1.2*	1.3**
70 to 79	-2.9 / 1996 / 0.5**	0.0	0.7**	...	1.2**
80 or older	-3.8 / 1996 / -0.1	-0.6	-0.2*	...	-0.1
Prostate					
20 to 39	3.4	...	7.3**	...	6.3
40 to 49	14.6** / 2003 / 7.0**	11.8*	18.3** / 2003 / 8.4**	13.7*	9.4**
50 to 59	8.3** / 2002 / 4.1**	6.5*	10.1** / 2003 / 4.5**	7.5*	6.2**
60 to 69	2.2**	...	4.7** / 2003 / 1.4*	3.2*	3.1**
70 to 79	-5.4 / 1997 / 0.3	-0.9	0.7**	...	1.7**
80 or older	-13.0* / 1996 / -2.4**	-4.0*	-2.2**	...	-1.4**
Breast					
20 to 39	-0.2	...	-0.5*	...	-0.1
40 to 49	0.1	...	0.1 / 2005 / 1.6*	0.5*	1.1**
50 to 59	1.9** / 2000 / -1.6**	-0.1	1.9** / 2001 / -1.4**	-0.2*	-0.6**
60 to 69	0.8* / 2003 / -1.2	0.1	1.6** / 2003 / -0.9**	0.5*	0.7*
70 to 79	-1.0**	...	-0.9**	...	-0.1
80 or older	-1.1**	...	0.2 / 2001 / -1.8**	-1.1*	-1.3**
Colorectal					
20 to 39	1.7** / 2005 / 6.6**	2.7*	1.3* / 2003 / 3.8**	2.4*	2.6**
40 to 49	-1.4 / 1998 / 1.4**	0.6	1.5**	...	1.8**
50 to 59	-4.3 / 1996 / 1.0**	0.2	1.2**	...	1.4**
60 to 69	0.1	...	1.1** / 2004 / -0.3	0.6*	0.5**
70 to 79	0.6**	...	1.4** / 2002 / 0.8**	1.1*	1.1**
80 or older	0.6 / 2002 / -0.9*	0.0	1.1** / 2003 / -0.7**	0.3*	0.2**
Lung and bronchus					
20 to 39	-2.4**	...	-2.2**	...	-2.3
40 to 49	-4.3* / 1998 / -0.7	-1.7*	-0.8**	...	-0.9*
50 to 59	-2.8** / 2005 / 0.8	-2.0*	-2.9** / 2005 / 0.1	-2.1*	-1.9**
60 to 69	-1.0**	...	-0.9**	...	-0.6
70 to 79	0.9**	...	1.0**	...	1.0**
80 or older	0.5 / 2000 / 2.4**	1.6*	2.1**	...	1.8**

APC = annual percent change; AAPC = average annual percent change; when no change in trend is detected, the APC and AAPC are identical

* statistically significant ($p < 0.05$)

** statistically significant ($p < 0.01$) (applicable only for APC)

... not applicable

Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

Substantial increases in prostate cancer prevalence proportions occurred among men in all age groups younger than 70. Average annual rate increases were highest at ages 40 to 49—ranging from 9.4% (ten-year) to 13.7% (five-year); the magnitude of the increase fell in each successively older age group. Among 70- to 79-year-old men, relatively small increases in prostate cancer occurred for durations of five and ten years, and no significant trend was observed for two-year duration. At age 80 or older, declining trends were significant.

For other leading cancers, no consistent age pattern emerged in the rate of change. Average annual rates of increase in prevalence proportions for colorectal cancer were highest (about

2.5%) in the 20-to-39 age group for each of the three durations. Within this age range, rates of increase were even higher in more recent years in two-year (6.6%) and five-year (3.8%) prevalence proportions. For lung and bronchial cancer, prevalence proportions decreased in age groups younger than 70, but rose in older age groups. Annual rates of decrease were highest in the 20-to-39 age group, at just over 2%. The highest rates of increase (about 2% per year) occurred among people aged 80 or older.

For breast cancer, age-specific changes over time in prevalence proportions were modest. Among women aged 50 to 59, however, the two- and five-year prevalence proportions rose at a rate of almost 2% per year until the early

2000s, and then fell about 1.5% annually until 2008. A similar, though slightly attenuated, pattern was observed in the 60-to-69 age group, with 2003 as the pivotal year.

Age-structure effects

For all cancers combined, average annual rates of increase in prevalence proportions were more than halved when the effects of aging of the population over the study period were taken into account. For example, when adjusted for age, the rate of increase in the five-year prevalence proportion changed from 2.1% to 1.0% per year (Table 1, Table 3).

For all but one of the individual cancers considered, increases in prevalence proportions were smaller (or decreases

Table 3
Two-, five- and ten-year age-standardized cancer prevalence proportion trends, by cancer type, Canada excluding Quebec, 1994 to 2008

Cancer type	Two-year (1994 to 2008)	AAPC	Five-year (1997 to 2008)	AAPC	Ten-year (2002 to 2008)
	APC / Trend change year / APC		APC / Trend change year / APC		APC
All cancers	-0.9 / 1997 / 0.8**	0.4*	1.0**	...	1.2**
Oral cavity and pharynx	-3.3** / 1999 / -0.6*	-1.5*	-3.0** / 2000 / -0.6**	-1.3*	-0.6*
Esophagus	0.7**	...	1.0**	...	1.7**
Stomach	-1.1**	...	-1.2** / 2004 / 0.4	-0.7*	-0.2
Colorectal	0.4**	...	1.2** / 2003 / 0.4*	0.9*	0.9**
Colon excluding rectum	0.2	...	1.0** / 2002 / 0.2	0.6*	0.5**
Rectum and rectosigmoid	0.9**	...	1.9** / 2005 / 0.4	1.5*	1.5**
Anus	5.1** / 2001 / -0.7	2.2*	4.9** / 2002 / 0.2	2.3*	1.6**
Liver	6.2**	...	6.7**	...	6.7**
Pancreas	1.8**	...	2.2**	...	2.5**
Larynx	-3.2**	...	-3.3**	...	-3.2**
Lung and bronchus	-0.6** / 2004 / 0.9	-0.2	-0.4** / 2005 / 1.0**	0.0	0.2
Soft tissue	1.0** / 2004 / 5.7**	2.3*	1.3** / 2005 / 5.1**	2.3*	2.9**
Skin melanoma	1.6**	...	2.1** / 2000 / 1.5**	1.6*	1.5**
Breast	0.4 / 2000 / -0.8**	-0.3	0.9** / 2001 / -0.7**	-0.1	0.0
Cervix uteri†	-1.9**	...	-1.8**	...	-1.6**
Corpus uteri†	-1.7 / 1996 / 0.7**	0.4	0.5** / 2006 / 1.3*	0.7*	0.7**
Ovary†	-1.4* / 1998 / 0.4**	-0.1	-0.3 / 2001 / 1.1**	0.6*	0.7**
Prostate†	0.5	...	1.3**	...	1.5**
Testis†	1.1**	...	1.2**	...	1.2**
Bladder (including in situ)	-0.9**	...	-1.1**	...	-1.1**
Kidney and renal pelvis	0.9** / 2006 / 6.3*	1.7*	1.3** / 2006 / 3.1*	1.6*	1.7**
Brain	0.4**	...	0.2	...	0.2*
Thyroid	3.4* / 1999 / 8.7**	6.7*	3.1 / 2000 / 8.8**	7.2*	7.7**
Hodgkin lymphoma	0.0	...	0.0	...	0.1
Non-Hodgkin lymphoma	1.6**	...	2.0**	...	2.5**
Multiple myeloma	1.3**	...	2.1**	...	2.4**
Leukemias	0.9* / 2002 / 2.7**	1.7*	1.1** / 2002 / 3.0**	2.2*	2.9**

APC = annual percent change; AAPC = average annual percent change; when no change in trend is detected, the APC and AAPC are identical

† sex-specific population data used to derive prevalence proportions underlying trend analysis

* statistically significant ($p < 0.05$)

** statistically significant ($p < 0.01$) (applicable only for APC)

... not applicable

Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

were larger) based on age-standardized than on crude rates. The exception was testicular cancer—the annual rate of increase in the crude five-year prevalence proportion was 0.6%, but 1.2% when age-standardization was applied.

Age-standardization flattened the trends for some cancers with significantly increasing crude prevalence proportions (for example, breast, and lung and bronchus), and led to significantly declining trends for others (bladder and stomach).

Discussion

This analysis shows significant increases in prevalence proportions for most individual cancers and most prevalence durations studied. Increases were relatively large for liver and thyroid cancer, while prevalence proportions decreased for cancers of the larynx and cervix uteri. The greatest sex-specific disparity was for cancer of the lung and bronchus, which had begun to decline among men, but continued to increase among women. Increases in prostate cancer prevalence proportions were inversely related to age.

Cancer prevalence is a function of the incidence of and survival from the disease. One of the most important factors contributing to growth in the proportion of incident cancer cases in Canada is simply aging of the population, because the occurrence of most cancers increases with age. For all cancers combined, roughly half the reported average annual rate of increase for five- and ten-year prevalence, and almost three-quarters for two-year prevalence, were attributable to aging of the population during the study period. However, for individual cancers, the role of population aging in shaping prevalence trends varied considerably.

For liver cancer, both incidence and observed survival rose markedly over the study period^{5,17}; only about 20% of the increase in prevalence was due to aging of the population. Various explanations of rising liver cancer incidence in Canada have been suggested. These include increases in immigrants from countries

where hepatitis B and C virus infections and exposure to aflatoxins are more common¹⁸; rising incidence of hepatitis C infection linked to intravenous drug use and needle-sharing; and growing rates of obesity and diabetes.¹⁹ Five-year survival from liver cancer in Canada has nearly doubled since the early 1990s, but remains under 20%.^{5,6} In the United States, screening of at-risk groups and treatment of localized-stage tumours may have contributed to increasing survival.²⁰

Increases in thyroid cancer incidence rates, especially among young and middle-aged women, have been reported in countries around the world, and have been attributed to advancements in diagnostic techniques.^{21,22} A recent study from the United States, however, suggests that more detection cannot completely explain the increases noted in that country.²³

Rising prevalence proportions of anal cancer could be attributed to higher incidence, as survival did not improve over the study period. Only about 20% of the substantial increases in two- and five-year prevalence noted until the early 2000s were due to aging of the population, whereas virtually all of the smaller increase thereafter can be attributed to this factor. People infected with the human immunodeficiency virus (HIV) are much more susceptible to anal cancer.²⁴ Increases in incidence concomitant with the use of highly active antiretroviral treatment for HIV—leading to longer survival, and thus, greater potential for exposure of people at particular risk—have been observed in both Canada and the United States.^{17,25}

Some cancers for which the prevalence proportions increased most quickly are relatively uncommon, and therefore, even a sharp annual rate of increase does not make a great difference in their absolute prevalence. Liver cancer, for instance, was the least prevalent cancer studied, with a five-year prevalence proportion of 6.2 cases per 100,000 persons on January 1, 2008. For perspective, the corresponding figure for prostate cancer was nearly 100-fold higher (Appendix Table A).

What is already known on this subject?

- In Canada, the rate at which new cancer cases are diagnosed continues to rise.
- Survival from cancer is also increasing.
- Cancer prevalence trends are rarely published, and until now, have not been reported for Canada.

What does this study add?

- Statistically significant increases in prevalence proportions were observed for most individual cancers and most prevalence durations.
- Increases were relatively large for liver and thyroid cancer.
- Decreases occurred for cancers of the larynx and cervix uteri.
- The greatest sex-specific disparity was for cancer of the lung and bronchus, which had begun to decline in men, but continued to increase in women.
- Increases in prostate cancer prevalence proportions were inversely related to age.

For the most commonly diagnosed cancers, the impact of population aging varied. The strong relationship of population aging to prostate cancer prevalence is evidenced by the marked attenuation of the increase in prevalence proportions when the analysis was conducted using age-adjusted values. Nonetheless, rising trends for the age-standardized five- and ten-year prevalence proportions remained significant. These increases reflect rising incidence rates over the past decade, coupled with greatly improved observed survival proportions.^{5,17} Factors other than population aging that likely

contribute to rising incidence include lowering of the prostate-specific antigen threshold for biopsy, more extensive screening, and improved sensitivity of prostate biopsy.^{26,27}

For colorectal cancer, population aging accounted for roughly two-thirds of the rise in prevalence proportions. Longer survival⁵—attributed to earlier detection as a result of screening and improved treatment²⁸—likely accounts for the rest, as age-standardized colorectal cancer incidence rates declined slightly during the relevant period.¹⁷

Increases in breast cancer prevalence proportions were virtually all due to population aging; trends in age-standardized proportions for all durations studied were not significant.

Between the sexes, changes in the prevalence rate of lung cancer diverged. This discrepancy was due to sharper decreases in smoking prevalence in men since the mid-1960s.²⁹

Significant declines in the prevalence proportions of cancer of the larynx likely reflect declining incidence rates of this cancer,¹⁷ due to decreasing smoking rates.²⁹ Similarly, for cervical cancer, falling incidence rates of squamous cell carcinoma—the predominant type of cervical cancer—as a result of detection and treatment of pre-malignant lesions through Pap screening programs may account for decreases in prevalence.³⁰ Further declines in cervical cancer

incidence may occur with the introduction of a preventive vaccine against certain types of the human papilloma virus—the most important risk factor.

Limitations

Trends in prevalence proportions presented in this study were derived without data from the province of Quebec (see *Analytical techniques*)—where almost one-quarter of the Canadian population resides. The extent to which the results reflect trends in Canada as a whole is influenced by how similar prevalence trends in Quebec are to the rest of the country—a question that is difficult to answer. While accurate survival estimates for Quebec are not currently calculable using CCR data, crude incidence trends provide at least some insight. Over the study period, the rates of increase in the incidence of some of the most commonly diagnosed cancers (colorectal, breast, and lung and bronchus) were greater in Quebec than in Canada as a whole.⁴ Trends in prostate cancer incidence cannot be compared because case completeness for this cancer is problematic in the province of Quebec.³¹

The possibility that some persons counted as prevalent cancer cases may have been cured was not considered in this study. To estimate the number of prevalent cases that have not been cured, statistical approaches have been applied

to model “cure prevalence,”^{32,33} but such analyses were beyond the scope of this study. Nonetheless, even among people who have been cured, cancer treatment can lead to long-term or permanent physical and psychological after-effects.

Conclusion

This study presents the first Canadian cancer prevalence trend estimates to be reported. Trends in prevalence for an extensive list of cancers by time since diagnosis, sex and age group signal changes in the extent of disease in the Canadian population. Rising cancer prevalence proportions are due to increases in incidence, which partly result from the aging of the population, and to improvements in survival. Information about the degree to which changes in prevalence are occurring, and for which cancers in particular, is valuable for resource planning. ■

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Appendix

Table A

Prevalence proportion (per 100,000), by prevalence-duration, cancer type and sex, Canada excluding Quebec, January 1, 2008

Cancer type	Two-year			Five-year			Ten-year		
	Both sexes	Men	Women	Both sexes	Men	Women	Both sexes	Men	Women
All cancers	720.7	754.0	687.9	1,489.5	1,537.5	1,442.2	2,405.9	2,441.6	2,370.8
Oral cavity and pharynx	17.1	23.0	11.2	34.7	46.6	23.1	56.1	74.3	38.1
Esophagus	4.3	6.5	2.1	6.2	9.2	3.2	7.9	11.7	4.2
Stomach	8.8	11.3	6.4	15.0	19.1	10.9	21.3	26.8	16.0
Colorectal	93.3	104.5	82.2	191.4	211.2	171.9	300.1	325.6	275.0
Colon excluding rectum	61.8	64.9	58.8	126.9	131.3	122.7	200.1	203.3	196.9
Rectum and rectosigmoid	31.4	39.6	23.4	64.4	79.9	49.2	100.1	122.4	78.1
Anus	3.0	2.4	3.6	6.3	5.3	7.4	9.9	8.2	11.6
Liver	4.0	6.1	2.0	6.2	9.4	3.0	8.0	12.2	3.9
Pancreas	6.4	6.7	6.2	8.6	8.7	8.5	10.4	10.4	10.4
Larynx	4.7	7.9	1.5	10.0	16.6	3.4	16.5	27.4	5.7
Lung and bronchus	54.0	53.4	54.6	84.3	81.1	87.4	111.7	106.7	116.5
Soft tissue	5.4	6.2	4.7	10.9	12.2	9.6	17.2	18.9	15.5
Skin melanoma	30.6	32.2	29.1	66.5	69.1	64.0	112.3	113.7	110.9
Breast	116.3	1.8	229.0	262.5	4.1	516.9	458.6	6.3	903.7
Cervix uteri	...	...	14.6	...	...	32.5	...	...	60.3
Corpus uteri	...	...	47.0	...	...	103.0	...	...	176.2
Ovary	...	...	20.9	...	...	41.0	...	...	61.2
Prostate	...	280.4	...	...	610.0	...	...	1,016.2	...
Testis	...	10.2	...	...	24.7	...	...	46.8	...
Bladder (including in situ)	28.9	43.9	14.1	61.8	93.9	30.3	99.9	150.4	50.2
Kidney and renal pelvis	21.4	26.2	16.7	42.7	51.9	33.7	68.4	82.2	54.7
Brain	7.2	8.2	6.2	12.4	13.9	10.9	19.0	21.2	16.9
Thyroid	24.0	10.8	37.0	53.1	22.3	83.3	84.3	35.7	132.2
Hodgkin lymphoma	4.8	5.1	4.6	11.4	12.3	10.5	21.0	23.0	19.1
Non-Hodgkin lymphoma	31.6	34.4	28.8	65.9	71.4	60.5	103.0	109.6	96.5
Multiple myeloma	8.5	9.3	7.7	15.6	17.4	13.8	20.4	22.5	18.3
Leukemias	20.7	24.3	17.1	41.8	49.3	34.3	63.6	74.6	52.9
Other, unknown	39.9	39.3	40.5	78.5	77.7	79.3	119.0	117.1	120.9

... not applicable

Source: Canadian Cancer Registry—Statistics Canada and provincial/territorial cancer registries.

Adopting leisure-time physical activity after diagnosis of a vascular condition

by Pamela L. Ramage-Morin, Julie Bernier, Jason T. Newsom, Nathalie Huguet, Bentson H. McFarland and Mark S. Kaplan

Abstract

Background

A better understanding of factors associated with adopting leisure-time physical activity among people with chronic vascular conditions can help policy-makers and health care professionals develop strategies to promote secondary prevention among older Canadians.

Data and methods

Cross-sectional data from the 1994/1995 National Population Health Survey (NPHS), household component, and the 2007/2008 Canadian Community Health Survey were used to estimate the prevalence of inactivity. Longitudinal data from eight cycles (1994/1995 through 2008/2009) of the NPHS, household component, were used to examine the adoption of leisure-time physical activity, intentions to change health risk behaviours, and barriers to change.

Results

Over half (54%) of the population aged 40 or older were inactive during their leisure time in 2007/2008. A new vascular diagnosis was not associated with initiating leisure-time physical activity. Among the newly diagnosed, those with no disability or a mild disability had higher odds of undertaking leisure-time physical activity.

Interpretation

The majority of Canadians in mid- to late life are inactive. They tend to remain so when diagnosed with a vascular condition.

Keywords

aged, chronic disease, elderly, exercise, health promotion, lifestyle, middle age, public health, social environment

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Inactive lifestyles have been recognized as a threat to good health and a contributor to higher health care costs and premature death.¹⁻⁴ A lack of regular physical activity is associated with the development of chronic conditions including heart disease, hypertension and diabetes.^{5,6} Physical activity may help prevent these conditions—directly, through improved vascular health,^{6,7} or indirectly, through mechanisms such as weight control, stress reduction and quality of sleep.⁸ The benefits extend to secondary prevention, whereby active lifestyles help those who have already developed chronic conditions limit the progress or complications of the disease.⁸

Despite the highly promoted benefits of physical activity, most Canadians are relatively inactive. Fewer than 15% of adults aged 40 or older meet Canada's new physical activity guidelines.⁹ An estimated 40% of Canadians aged 40 to 59 average more than the recommended 10,000 steps per day; at ages 60 to 79, the figure is 20%.⁹

While never a positive experience, developing a chronic vascular disease may ultimately yield health benefits if it is a “wake-up call,” prompting inactive individuals to become more physically

active. In fact, changes in health behaviour after the onset of chronic conditions are well documented. For example, smoking cessation is more common among people newly diagnosed with conditions such as heart disease, stroke, cancer, diabetes and hypertension than among people without a new diagnosis.¹⁰⁻¹⁴ Intentional weight loss, dietary changes, lowering low density lipoprotein (LDL) cholesterol, and reduced alcohol consumption following adverse health events have also been reported.^{10,11,15,16}

Findings about changes in physical activity after the diagnosis of a chronic condition are less clear. Newsom et al.¹⁶ reported no significant increase in the percentage of people who became active after being diagnosed; on the contrary, following a diagnosis of cancer, stroke or lung disease, people were less likely to report regular vigorous exercise. Neutal¹² found a small decrease in inactive behaviour after a hypertension diagnosis, whereas van Gool et al.¹⁷ reported increases in the likelihood of inactive behaviour after diagnosis of chronic conditions. Allegrante et al.¹¹ found significant positive changes in overall physical activity and strength training among people with coronary artery disease.

This study uses a large, population-based, longitudinal sample of adults to examine: 1) whether inactive Canadians aged 40 or older who are free of vascular disease become active after a new vascular diagnosis; 2) factors associated with becoming active during leisure time; and 3) changes or intentions to change health behaviours, including physical activity, among the newly diagnosed.

Methods

Data source

The “inactive” percentage of the population was estimated from the 1994/1995 cross-sectional file of the National Population Health Survey (NPHS) and from the Canadian Community Health Survey (CCHS) - Annual component 2007/2008. Data on changes in physical activity are from eight cycles (1994/1995 through 2008/2009) of the longitudinal household file of the NPHS. Descriptions of the NPHS and CCHS methodologies are available in published reports.¹⁸⁻²⁰ Further details about the NPHS and CCHS are available from the respective survey documentation at: www.statcan.gc.ca.

Definitions

To measure *leisure-time physical activity*, respondents were asked to report the frequency and duration of their

participation in a variety of activities over the past three months (Appendix Table A).^{21,22} Average daily energy expenditure (EE) for all activities was calculated as:

$$EE \text{ (kcal/kg/day)} = \text{sum of } ((N_i * D_i * MET \text{ value})/365), \text{ where:}$$

N_i = number of times respondent engaged in activity_{*i*} over a 12-month period;

D_i = average duration in hours of activity_{*i*};

MET = energy cost of activity expressed as kilocalories expended per kilogram of body weight per hour of activity (kcal/kg/hour).

MET values are typically expressed in three intensity levels (low, medium, high). Because NPHS respondents were not asked to specify the intensity of their activities, MET values corresponding to the low intensity value of each activity were used, an approach adopted from the *Canadian Fitness and Lifestyle Research Institute*. Respondents were classified as either *inactive* (EE < 1.5) or *active* (EE ≥ 1.5). Those who were inactive at baseline and active two years later were classified as *became active*.

Respondents reported if a health professional had diagnosed them with chronic conditions that had lasted or were expected to last six months or more. Those with high blood pressure, heart disease, and/or diabetes were classified as having a *vascular disease*. Those who took insulin in the past month were considered to have diabetes. Once a vascular condition was reported, respondents were considered to have the condition in every subsequent cycle.

Level of *disability* accounted for the presence and severity of chronic conditions that interfere with physical activity but were not included in the models (for example, arthritis). Level of *disability* was based on the Health Utility Index (HUI3) developed at McMaster University.²³⁻²⁵ Functional health, based on vision, hearing, speech, mobility, dexterity, cognition, emotion, pain and discomfort, was scored and categorized into levels of disability: none (1.00), mild (0.89 to 0.99), moderate (0.70 to

0.88) or severe (less than 0.70), and then dichotomized to *no/mild disability* versus *moderate/severe disability*.

Earlier work,^{26,27} confirmed using the 1994/1995 NPHS longitudinal sample, identified two distinct factors within the mastery scale: *fatalism* and *control*. The first five statements from the mastery module loaded onto *fatalism* (Eigenvalue 2.9; Cronbach's alpha 0.8):

1. You have little control over the things that happen to you.
2. There is really no way you can solve some of the problems you have.
3. There is little you can do to change many of the important things in your life.
4. You often feel helpless in dealing with problems of life.
5. Sometimes you feel that you are being pushed around in life.

Responses were scaled from 0 (strongly agree) to 4 (strongly disagree) and summed for a potential range of 0 to 20. Individuals with a total below the median (less than 14) were considered to be more fatalistic.

The final two statements loaded onto *control* (Eigenvalue 1.1; Cronbach's alpha 0.5):

6. What happens to you in the future mostly depends on you.
7. You can do just about anything you really set your mind to.

Responses were scaled from 0 (strongly disagree) to 4 (strongly agree) and summed for a potential range of 0 to 8. Individuals who scored below the median (less than 6) were classified as having a low sense of *control*. Cycles 2 and 3 of the NPHS excluded the mastery module; analyses that included fatalism and control were based on the remaining cycles.

Perceived *social support* was based on four yes/no questions in the first two NPHS cycles (Appendix Table B). Respondents who answered “yes” to all four questions had *high social support*. For the remaining cycles, perceived social support was measured using the Emotional or Informational Support -

MOS Subscale.²⁸ The eight questions were answered on a five-point scale: none of the time (score 1), a little of the time (2), some of the time (3), most of the time (4), or all of the time (5). People who responded “some,” “most,” or “all of the time” to all eight questions were classified as having *high social support*.

Analytical techniques

The analysis was completed using SAS software Version 9.1 (Copyright, 2002–2003 SAS Institute Inc.). Data were weighted using age, sex, province, and non-response adjustments to ensure consistency with census-based estimates for the reference year of the survey. To account for survey design effects of the NPHS and CCHS, p-values were estimated, and significance tests were performed using the bootstrap technique.^{29,30}

Cross-sectional analyses

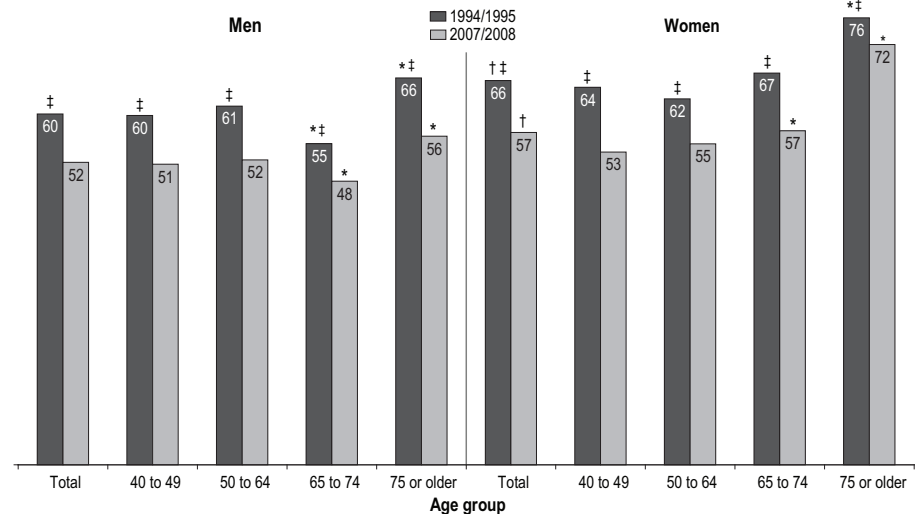
Based on cycle 1 (1994/1995) of the NPHS household component and the 2007/2008 CCHS, weighted frequencies and cross-tabulations were calculated to estimate the percentage of the household population aged 40 or older who were inactive, by sex and age group.

Longitudinal analyses

Weighted frequencies were used to estimate the percentage of the household population aged 40 or older who were inactive or active at the first NPHS cycle. In the seven subsequent cycles (1996/1997 through 2008/2009), estimates were calculated of the percentage of the remaining cohort who, from one cycle to the next, remained inactive or active, or who became inactive or active.

The multivariate logistic regression was based on data from eight cycles of the NPHS. The data were pooled to create seven cohorts of observations with baseline years starting at 1994/1995 and follow-up two years later (Appendix Table C). The study sample was limited to respondents who, at each baseline year, were aged 40 or older, inactive and free of vascular disease, and who provided a

Figure 1
Percentage inactive during leisure time, by age group and sex, household population aged 40 or older, Canada excluding territories, 1994/1995 and 2007/2008



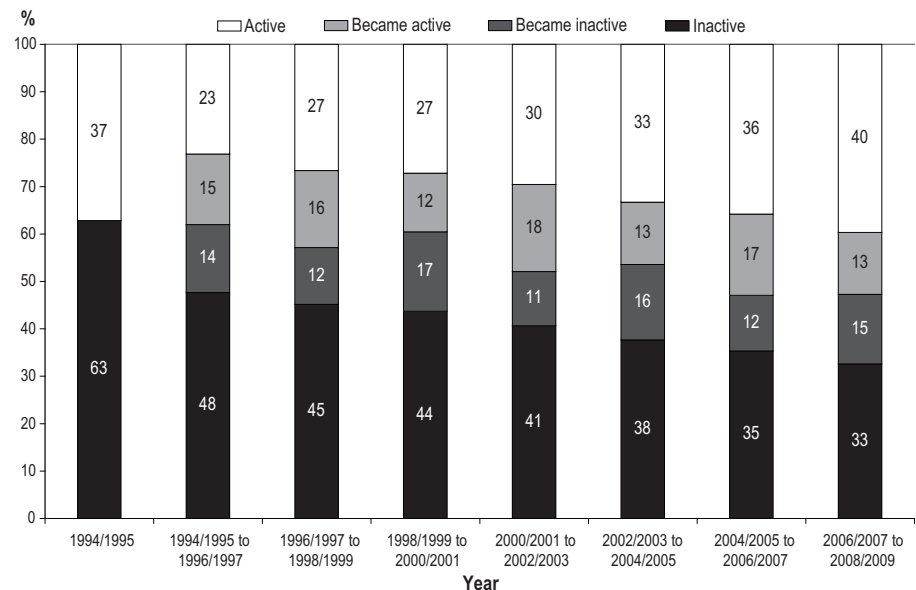
* significantly different from previous age group in same year ($p < 0.05$)

† significantly different from men in same year ($p < 0.05$)

‡ significantly different from 2007/2008 ($p < 0.05$)

Source: 1994/1995 National Population Health Survey, cross-sectional sample; 2007/2008 Canadian Community Health Survey.

Figure 2
Percentage who maintained or changed leisure-time activity level over two-year period, household population aged 40 or older at baseline, Canada excluding territories, 1994/1995 to 2008/2009



Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).

full response at baseline and follow-up. Respondents continued to contribute records to the analyses for every cycle in which they met the baseline criteria.

The second cycle of the NPHS included questions about improvements in health behaviour, and barriers and intentions to improve health behaviour. The analysis of associations between a new vascular diagnosis and these variables was based on the first cohort of observations (1994/1995 to 1996/1997).

All analyses were stratified by gender.

Results

In 2007/2008, 54% of people aged 40 or older were inactive during their leisure time, down from 63% in 1994/1995. This change over time was evident across all age groups (Figure 1).

Seniors aged 75 or older were more likely than younger adults to be inactive. However, men aged 65 to 74 were *less* likely than those aged 50 to 64 to be inactive. Overall, women were more likely than men to be inactive.

Between consecutive cycles of the NPHS, close to 30% of the cohort changed their leisure-time physical activity level, with approximately equal numbers becoming active if they were inactive, or becoming inactive if they were active (Figure 2).

For men, a new diagnosis of a vascular condition was not associated with level of physical activity at follow-up (Table 1). On the other hand, newly diagnosed women had lower odds (0.8) of being active at follow-up, although this association lost significance when other factors were taken into account (Table 2). In the adjusted models, younger age and having no or mild disabilities were associated with higher odds of becoming active for women. Higher education was associated with becoming active for both sexes.

Former smokers of both sexes had higher odds of becoming active than did current smokers. In the adjusted models, this relationship persisted, but no difference was apparent between

those who had never smoked and current smokers.

People who were more fatalistic and those with a lower sense of control had lower odds of becoming active, although these associations did not persist when potential confounders were taken into account.

The results demonstrated sex-specific associations between social resources and leisure-time physical activity. Men with a regular medical doctor and high social support had higher odds of becoming active, although the significance of the latter was attenuated in the adjusted model. For women, having a partner and high social support were significant, but again, social support lost significance when other confounders were considered.

Although a vascular diagnosis was generally not associated with becoming active, some people who were newly diagnosed did undertake leisure-time physical activity. The analysis was repeated, based only on respondents with a new vascular diagnosis (Tables 3 and 4). Even when other confounders were taken into account, people with no disability or a mild disability had significantly higher odds of becoming active than did those with a moderate or severe disability. The odds of becoming active were lower for men who were fatalistic and higher for women with a partner, although both associations lost significance in the full models.

Further analyses examined associations between a vascular diagnosis and actual changes and intentions to change health behaviours. The odds of having made *any* improvements in health over the past 12 months were no different between those with and without a new vascular diagnosis (Table 5). Among women who had actually improved their health behaviour, those with a new vascular diagnosis had lower odds of reporting that the most important change was increased exercise. Barriers to making efforts to improve health included being too tired (men) and disability or a health problem (women).

What is already known on this subject?

- Relatively few older Canadians attempt to improve their health through exercise or other initiatives, often citing a lack of willpower as a barrier.
- Despite some tendency for people to adopt better health risk behaviours such as smoking cessation, weight loss, dietary changes and reduced alcohol consumption when they face a new chronic condition, most individuals do not make needed changes.
- Previous research has examined changes in physical activity following diagnosis of a new chronic condition, but the evidence is inconsistent.

What does this study add?

- Among Canadians aged 40 or older, 57% of women and 52% of men were inactive in their leisure time in 2007/2008.
- A new vascular diagnosis was not associated with becoming active among people in mid- to late-life.
- Having a regular doctor (men) and living with a spouse/partner (women) were associated with adopting leisure-time physical activity.
- Among people newly diagnosed with a vascular condition, level of disability was the main factor that accounted for whether they engaged in more leisure-time physical activity.

Looking to the future, women with a new vascular diagnosis had lower odds of reporting that they intended to try to improve their physical health in the next year. For those who planned to make changes, having a vascular diagnosis was not associated with the intention to start or increase exercise.

Adopting leisure-time physical activity after diagnosis of a vascular condition • Research article

Table 1

Odds ratios relating selected characteristics to becoming active, inactive male household population aged 40 or older free of vascular disease at baseline, Canada excluding territories, 1994/95 to 2008/2009

Characteristics	Unadjusted odds ratio	Model 1			Model 2			Model 3			Model 4		
		95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio
		from	to		from	to		from	to		from	to	
New vascular diagnosis													
Yes	0.9	0.7	1.1	0.9	0.7	1.1	0.9	0.7	1.1	0.9	0.7	1.2	
No [†]	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Disability													
No or mild	1.2	1.0	1.4	1.1	1.0	1.4	1.1	1.0	1.4	1.1	0.9	1.3	
Moderate or severe [†]	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
At baseline													
Socio-demographic													
Age group													
40 to 49	1.3	1.0	1.9	1.1	0.8	1.6	1.2	0.9	1.7	1.2	0.8	1.8	
50 to 64	1.3	0.9	1.9	1.2	0.8	1.7	1.3	0.9	1.8	1.3	0.9	2.0	
65 to 74	1.4	1.0	2.0	1.4	1.0	1.9	1.4	1.0	2.0	1.5	1.0	2.4	
75 or older [†]	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Education													
Postsecondary graduation	1.3*	1.1	1.6	1.3*	1.1	1.6	1.3*	1.1	1.6	1.3*	1.0	1.6	
Less than postsecondary graduation [†]	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Health behaviour													
Smoking													
Never	1.3*	1.0	1.6	...	...	...	1.2	1.0	1.6	...	...	...
Former	1.4*	1.2	1.7	...	...	...	1.4*	1.2	1.7	...	...	...
Current smoker [†]	1.0	...	...	...	...	...	1.0	...	...	...	...	...
Personal characteristics													
Fatalism[‡]													
High	0.8*	0.7	0.9	...	...	...	...	...	...	0.9	0.7	1.0	
Low [†]	1.0	...	...	...	...	...	...	...	...	1.0	...	...
Control[‡]													
Low	0.8*	0.6	1.0	...	...	...	...	...	...	0.8	0.6	1.0	
High [†]	1.0	...	...	...	...	...	...	...	...	1.0	...	...
Social resources													
Has regular medical doctor													
Yes	1.3*	1.0	1.6	...	...	...	...	...	...	...	...	...
No [†]	1.0	...	...	...	...	...	...	...	...	...	...	...
High social support													
Yes	1.3*	1.1	1.6	...	...	...	...	...	...	...	...	...
No [†]	1.0	...	...	...	...	...	...	...	...	...	...	...
Married/Common-law/Living with partner													
Yes	1.2	1.0	1.4	...	...	...	...	...	...	...	...	...
No [†]	1.0	...	...	...	...	...	...	...	...	...	...	...

[†] reference category

[‡] based on cycles 1 and 4 through 8

* significantly different from reference category (p<0.05)

... not applicable

Note: Because of rounding, some odds ratios with lower or upper confidence limit of 1.0 were statistically significant.

Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).

Table 2

Odds ratios relating selected characteristics to becoming active, inactive female household population aged 40 or older free of vascular disease at baseline, Canada excluding territories, 1994/95 to 2008/2009

Characteristics	Unadjusted odds ratio	Model 1			Model 2			Model 3			Model 4		
		95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio
		from	to		from	to		from	to		from	to	
New vascular diagnosis													
Yes	0.8*	0.6	1.0	0.9	0.7	1.1	0.9	0.7	1.1	0.8	0.6	1.0	0.9
No†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0
Disability													
No or mild	1.8*	1.6	2.1	1.7*	1.5	2.0	1.7*	1.4	2.0	1.7*	1.4	2.0	1.6*
Moderate or severe†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0
At baseline													
Socio-demographic													
Age group													
40 to 49	2.5*	1.9	3.4	1.9*	1.4	2.6	1.9*	1.4	2.6	2.1*	1.4	3.1	1.8*
50 to 64	2.8*	2.1	3.8	2.3*	1.7	3.1	2.3*	1.7	3.1	2.4*	1.6	3.5	2.2*
65 to 74	2.4*	1.8	3.3	2.1*	1.5	2.9	2.1*	1.5	2.8	2.3*	1.5	3.5	2.0*
75 or older†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0
Education													
Postsecondary graduation	1.4*	1.2	1.6	1.3*	1.1	1.5	1.3*	1.1	1.5	1.2*	1.0	1.4	1.3*
Less than postsecondary graduation†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0
Health behaviour													
Smoking													
Never	1.0	0.9	1.2	...	...	...	1.0	0.9	1.2	...	...	...	...
Former	1.4*	1.2	1.7	...	...	...	1.4*	1.1	1.6	...	...	...	...
Current smoker†	1.0	...	...	...	...	...	1.0	...	...	...	...	...	...
Personal characteristics													
Fatalism‡													
High	0.8*	0.7	1.0	...	...	...	...	...	...	0.9	0.8	1.1	...
Low†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...
Control‡													
Low	0.8*	0.6	0.9	...	...	...	...	...	...	0.9	0.7	1.1	...
High†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...
Social resources													
Has regular medical doctor													
Yes	1.2	0.9	1.5	...	...	...	...	...	...	...	...	...	1.2
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0
High social support													
Yes	1.4*	1.1	1.6	...	...	...	...	...	...	...	...	...	1.2
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0
Married/Common-law/Living with partner													
Yes	1.4*	1.2	1.7	...	...	...	...	...	...	...	...	...	1.3*
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0

† reference category

‡ based on cycles 1 and 4 through 8

* significantly different from reference category (p<0.05)

... not applicable

Note: Because of rounding, some odds ratios with lower or upper confidence limit of 1.0 were statistically significant.**Source:** 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).

Table 3
Odds ratios relating selected characteristics to becoming active, inactive male household population aged 40 or older with new vascular disease diagnosis, Canada excluding territories, 1994/95 to 2008/2009

Characteristics	Unadjusted odds ratio	95% confidence interval		Model 1			Model 2			Model 3			Model 4		
		from	to	Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval	
					from	to		from	to		from	to		from	to
New vascular diagnosis															
Yes	...	...	...	...	...	...	...	...	...	...	...	...	...	...
No†	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Disability															
No or mild	1.9*	1.2	2.9	1.9*	1.2	2.9	1.9*	1.2	2.9	2.0*	1.1	3.6	1.7*	1.1	2.6
Moderate or severe†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
At baseline															
Socio-demographic															
Age group															
40 to 49	2.7*	1.1	7.1	2.2	0.8	5.8	2.3	0.9	6.1	2.8	0.7	12.0	2.0	0.7	5.4
50 to 64	2.5	1.0	6.6	2.2	0.8	5.8	2.2	0.8	6.1	3.3	0.8	13.9	2.1	0.7	5.7
65 to 74	2.7	1.0	7.7	2.6	0.9	7.6	2.6	0.9	7.7	6.1*	1.3	27.3	2.6	0.9	7.6
75 or older†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Education															
Postsecondary graduation	1.2	0.7	2.0	1.1	0.6	1.8	1.1	0.6	1.8	1.1	0.6	1.9	1.1	0.6	1.8
Less than postsecondary graduation†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Health behaviour															
Smoking															
Never	1.2	0.7	2.3	...	...	...	1.2	0.6	2.3	...	...	...	...	...	...
Former	1.1	0.7	1.9	...	...	...	1.2	0.7	2.0	...	...	...	...	...	...
Current smoker†	1.0	...	...	...	...	...	1.0	...	...	...	...	...	...	...	...
Personal characteristics															
Fatalism‡															
High	0.5*	0.3	1.0	...	...	...	...	...	...	0.6	0.3	1.1	...	...	...
Low†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...	...	...
Control‡															
Low	1.0	0.6	1.9	...	...	...	...	...	...	1.5	0.7	3.0	...	...	...
High†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...	...	...
Social resources															
Has regular medical doctor															
Yes	0.8	0.4	1.8	...	...	...	...	...	...	...	...	...	0.8	0.4	1.8
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...
High social support															
Yes	1.2	0.7	2.2	...	...	...	...	...	...	...	...	...	1.0	0.6	1.9
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...
Married/Common-law/Living with partner															
Yes	1.3	0.7	2.2	...	...	...	...	...	...	...	...	...	1.1	0.6	2.0
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...

† reference category

‡ based on cycles 1 and 4 through 8

* significantly different from reference category (p<0.05)

... not applicable

Note: Because of rounding, some odds ratios with lower or upper confidence limit of 1.0 were statistically significant.

Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).

Table 4

Odds ratios relating selected characteristics to becoming active, inactive female household population aged 40 or older with new vascular disease diagnosis, Canada excluding territories, 1994/95 to 2008/2009

Characteristics	Model 1						Model 2			Model 3			Model 4		
	Unadjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval	
		from	to		from	to		from	to		from	to		from	to
New vascular diagnosis															
Yes	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
No†	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Disability															
No or mild	2.5*	1.6	3.9	2.5*	1.6	3.8	2.5*	1.6	3.8	2.8*	1.6	4.9	2.3*	1.5	3.6
Moderate or severe†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
At baseline															
Socio-demographic															
Age group															
40 to 49	3.6*	1.7	7.5	2.5*	1.1	5.2	2.5*	1.1	5.4	1.6	0.7	3.9	2.1	0.9	4.5
50 to 64	2.4*	1.2	5.0	1.9	0.9	4.1	2.0	0.9	4.2	1.1	0.5	2.6	1.7	0.8	3.7
65 to 74	2.4*	1.1	5.4	1.8	0.8	4.1	1.8	0.8	4.1	1.3	0.5	3.3	1.7	0.7	3.7
75 or older†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Education															
Postsecondary graduation	1.3	0.9	2.1	1.2	0.8	1.9	1.2	0.8	1.9	1.5	0.9	2.6	1.2	0.8	1.9
Less than postsecondary graduation†	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...	1.0	...	...
Health behaviour															
Smoking															
Never	1.0	0.6	1.7	...	...	...	1.0	0.6	1.8	...	...	...	...	...	...
Former	1.1	0.7	1.9	...	...	...	1.2	0.7	2.0	...	...	...	...	...	...
Current smoker†	1.0	...	...	...	...	...	1.0	...	...	...	...	...	...	...	...
Personal characteristics															
Fatalism‡															
High	1.0	0.6	1.6	...	...	...	...	...	...	1.2	0.7	2.1	...	...	...
Low†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...	...	...
Control‡															
Low	0.7	0.4	1.3	...	...	...	...	...	...	0.9	0.5	1.8	...	...	...
High†	1.0	...	...	...	...	...	...	...	...	1.0	...	...	...	...	...
Social resources															
Has regular medical doctor															
Yes	0.6	0.3	1.3	...	...	...	...	...	...	...	...	...	0.8	0.3	1.7
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...
High social support															
Yes	1.3	0.7	2.2	...	...	...	...	...	...	...	...	...	1.2	0.7	2.2
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...
Married/Common-law/Living with partner															
Yes	1.5*	1.0	2.3	...	...	...	...	...	...	...	...	...	1.2	0.8	1.9
No†	1.0	...	...	...	...	...	...	...	...	...	...	...	1.0	...	...

† reference category

‡ based on cycles 1 and 4 through 8

* significantly different from reference category (p<0.05)

... not applicable

Note: Because of rounding, some odds ratios with lower or upper confidence limit of 1.0 were statistically significant.

Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).

Table 5

Odds ratios relating new vascular diagnosis to improvements in health behaviour, and barriers to and intentions to improve health behaviour, by sex, inactive household population aged 40 or older in 1994/1995, Canada excluding territories, 1996/97

	Men			Women		
	Unadjusted odds ratios	95% confidence interval		Unadjusted odds ratios	95% confidence interval	
		from	to		from	to
Improvements						
Attempted to improve health in past 12 months						
New vascular diagnosis						
Yes	1.4	1.0	2.0	1.1	0.8	1.6
No†	1.0	...	...	1.0	...	...
Increased exercise						
New vascular diagnosis						
Yes	1.0	0.6	1.6	0.6*	0.4	1.0
No†	1.0	...	...	1.0	...	...
Barriers						
Too tired						
New vascular diagnosis						
Yes	5.9*	1.5	22.9	1.4	0.4	4.8
No†	1.0	...	...	1.0	...	...
Disability/Health problem						
New vascular diagnosis						
Yes	3.1	1.0	10.3	5.1*	2.2	11.7
No†	1.0	...	...	1.0	...	...
Intentions						
Intend to improve physical health in next year						
New vascular diagnosis						
Yes	1.0	0.5	1.7	0.6*	0.4	0.9
No†	1.0	...	...	1.0	...	...
Intend to start/increase exercise						
New vascular diagnosis						
Yes	0.8	0.4	1.5	1.0	0.5	1.8
No†	1.0	...	...	1.0	...	...

[†] reference category

* significantly different from reference category ($p < 0.05$)

... not applicable

Note: Because of rounding, odds ratios with upper confidence limit of 1.0 was statistically significant.

Source: 1994/1995 and 1996/1997 National Population Health Survey, longitudinal sample (square).

Discussion

This study of a large population-based sample found that inactive adults in mid- to late-life who had a new vascular diagnosis (hypertension, heart disease or diabetes) did not become more active.

It was hypothesized that individuals' sense of mastery (fatalism and control) may influence their behaviour following a new vascular diagnosis. The expectation was that those with higher

mastery would be more inclined to adopt leisure-time physical activity. Earlier work has shown that a higher sense of mastery is associated with positive self-perceived health among people already experiencing chronic conditions,^{31,32} and that older individuals with a higher sense of mastery declined significantly less over time than did those with a lower sense of mastery.³³ One of several possible explanations is that people with a greater sense of mastery would be more likely to

engage in health-promoting behaviours and use preventive health services.^{34,35} Results from this study only weakly support this suggestion, as associations between mastery and becoming active were found only in unadjusted models.

It is understandable that inactive people remain so following the setback of a new chronic condition. The NPHS revealed barriers to improving physical health among those with a new diagnosis: being too tired (men) and a disability or health problem (women). These are common barriers among the general population,³⁶ so it is not unexpected that they inhibit physical activity among people coping with new chronic conditions. Some studies have suggested that older people may fear that physical activity will be painful or cause injury.³⁷

Smoking may be a key to other changes in health behaviour. This study and others show that former smokers have higher odds of becoming active than do current smokers.³⁵ However, Allegrante et al.¹¹ suggest that physical activity is a "gateway" behaviour; once changes are made in this domain, others follow. In contrast, Newsom et al.³⁸ found that important health behaviours, including exercise and smoking, are largely independent, and therefore, a change in one would not necessarily lead to a change in others.

Social resources may influence the pursuit of more active lifestyles. This study demonstrated that having a regular doctor (men) and living with a spouse or partner (women) were significantly associated with becoming active. These are potential sources of support, which is important in helping older people become more active.³⁹

Social norms may also play a role.³⁷ The majority of Canadians are inactive, especially at older ages.⁹ Unlike changes such as smoking cessation (in Canada, where non-smokers are the majority,⁴⁰ smokers conform by quitting), becoming active is contrary to the norm. Furthermore, stereotypes of older people as frail and disinclined to make and benefit from lifestyle changes create other barriers to becoming more active.^{41,42}

It may also be that changes in physical activity were not detected in the NPHS. Respondents might have become more active, but not enough to change categories from “inactive” to “active.” However, this is unlikely. Preliminary analyses of changes in estimated energy expenditure between baseline and follow-up suggest that it was not a classification issue; inactive people really tended to remain that way.

Yet even while remaining inactive, respondents may have made progress in the “process” of becoming active. The Transtheoretical Model of Behaviour Change (TTM) outlines five stages: pre-contemplation, contemplation, planning, action, and maintenance.^{43,44} Diagnosis of a vascular condition could prompt movement through the early stages. Nonetheless, when respondents were asked about intentions to improve their physical health, diagnosis of a vascular condition was not associated with intentions to change. In fact, women newly diagnosed with a vascular condition had lower odds of intending to change. This is consistent with an earlier study of older Canadians.⁴⁵

Limitations

Attrition due to non-response is a limitation in longitudinal research. Refusal to participate in the NPHS and loss to follow-up constitute non-response. Of the 17,598 observations that met the baseline inclusion criteria (40 or older, inactive, no vascular disease, and full response), 1,349 (7.7%) were excluded because of non-response at follow-up (Appendix Table C). A further 397 (2.3%) were excluded because of death, and 109 (0.6%), because of institutionalization. Older people and those with less than postsecondary graduation were more likely to be non-responders; there was no difference between men and women (data not shown). Attrition introduces a potential selection bias, because younger and more educated respondents may differ in terms of physical activity.

Although the study design involved pooling of repeated measures to

maximize sample size, relatively few records showed respondents becoming active over the two-year period, especially those newly diagnosed with a vascular condition (Appendix Table C). The small sample sizes increase the possibility of type II errors, whereby power may be insufficient to detect real associations between some independent variables and changes in physical activity.

The NPHS collects self-reported data, which are limited by recall and social desirability biases. Hypertension, heart disease, diabetes, and the use of insulin are not verified by any other source. Other health conditions that may be related to physical activity were not included in the study. However, the multivariate models controlled for disability in order to account for other conditions and for the severity of the vascular conditions.

The physical activity variable is limited to leisure-time activities; physical activity at work, during rehabilitation, and in other non-leisure domains was excluded. Consequently, respondents' overall level of physical activity may be underestimated; some studies suggest that non-leisure activities, such as walking or cycling for transportation, account for a substantial share of total activity.⁴⁶ Even so, older people are more likely than youth to be inactive in all domains of their life.⁴⁶

No gold standard is available for measuring physical activity; potential problems and biases exist with both direct and indirect methods.⁴⁸ Earlier work reported a relatively low correlation between directly measured and self-reported physical activity, and the direction of the differences was inconsistent—sometimes self-reports were higher; other times, lower.⁴⁷ Despite the potential problems, self-report is an accepted method for collecting physical activity data in large population surveys such as the NPHS.

The list of physical activities varied slightly by NPHS cycle (Appendix Table

A), so some “changes” may result from the inclusion or exclusion of particular activities. As well, between cycles, some respondents may have increased their leisure-time activity and then relapsed. Such changes would not be detected except perhaps in the sub-analysis when they were asked if they had done anything to improve their health in the past 12 months.

A wide range of factors that may influence whether a person becomes physically active after the diagnosis of a chronic condition are not collected by the NPHS. These include the attitudes and behaviours of family and friends, family history of disease and lifestyle, the availability and accessibility of rehabilitation programs, and the physical environment such as safe places to walk and recreational facilities.

Conclusion

Evidence from this study indicates that for Canadians in mid- to late life, a new diagnosis of a vascular condition was not associated with becoming more physically active during their leisure time. However, some people who were newly diagnosed did become active—those with no disability or a mild disability had higher odds of undertaking leisure-time physical activity. Further investigation is required to assess the extent to which older adults recognize physical activity as a viable approach to secondary prevention, the barriers older people, especially those with chronic conditions and disabilities, face in adopting more active lifestyles, and the support required to help this population become more active. ■

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Appendix

Table A
Leisure-time physical activities included in longitudinal component of National Population Health Survey, by year

Activity	1994/1995 (cycle 1)	1996/1997 (cycle 2)	1998/1999 (cycle 3)	2000/2001 (cycle 4)	2002/2003 (cycle 5)	2004/2005 (cycle 6)	2006/2007 (cycle 7)	2008/2009 (cycle 8)
Walking for exercise	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gardening or yard work	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Swimming	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bicycling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Popular or social dance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Home exercises	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ice hockey	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ice skating	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
In-line skating/Rollerblading	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Jogging/Running	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Golfing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exercise class/Aerobics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cross-country skiing	Yes	Yes	No	No	No	No	No	No
Downhill skiing/Snowboarding	Yes/No	Yes/No	Yes/No	Yes/No	Yes	Yes	Yes	Yes
Bowling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseball/Softball	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tennis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weight-training	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fishing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Volleyball	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yoga/Tai-chi	Yes	No	No	No	No	No	No	No
Basketball	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample, household component.

Table B
Social support questions in National Population Health Survey, by year and cycle

Year/Cycle	Questions
1994/1995 and 1996/1997† Cycles 1 and 2	Do you have someone... 1. you can confide in or talk to about your private feelings or concerns? 2. you can really count on to help you out in a crisis situation? 3. you can really count on to give you advice when you are making important personal decisions? 4. who makes you feel loved and cared for?
1998/1999 to 2008/2009‡ Cycles 3 to 8	How often is support available to you if you need someone... 1. to listen to you when you need to talk? 2. to give you advice about a crisis? 3. to give you information in order to help you understand a situation? 4. to confide in or talk to about yourself or your problems? 5. whose advice you really want? 6. to share your most private worries and fears with? 7. to turn to for suggestions about how to deal with a personal problem? 8. who understands your problems?

† Health Statistics Division, Statistics Canada.

‡ Sherbourne CD, Stewart AL. The MOS social support survey. *Social Science and Medicine* 1991; 32(6): 705-14.

Table C
Sample sizes for longitudinal analysis: 40 or older, inactive, no vascular disease, and full response at baseline, household population

Cohort	Baseline (time 1)	Follow-up (time 2)	Eligible at baseline	Excluded at follow-up			Study sample			Inactive at follow-up		Active at follow-up		Vascular diagnosis at follow-up		Inactive and vascular diagnosis at follow-up		Active and vascular diagnosis at follow-up	
				Non- response	Dead	Insti- tution	Total	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
1	1994/1995	1996/1997	3,341	204	95	25	3,017	1,290	1,727	938	1,336	320	378	135	194	99	148	30	45
2	1996/1997	1998/1999	3,097	191	79	22	2,805	1,229	1,576	838	1,156	361	409	98	148	64	115	29	33
3	1998/1999	2000/2001	2,682	198	52	18	2,414	1,065	1,349	746	998	261	321	79	142	51	97	21	41
4	2000/2001	2002/2003	2,576	229	51	17	2,279	994	1,285	655	873	312	390	95	109	63	86	28	21
5	2002/2003	2004/2005	2,137	202	50	12	1,873	827	1,046	589	767	226	267	84	87	59	62	25	23
6	2004/2005	2006/2007	2,075	137	38	10	1,890	816	1,074	492	662	277	361	69	70	44	44	19	22
7	2006/2007	2008/2009	1,690	188	32	5	1,465	623	842	424	555	183	269	43	57	36	40	6	14
Total			17,598	1,349	397	109	15,743	6,844	8,899	4,682	6,347	1,940	2,395	603	807	416	592	158	199

Note: Non-response is composed of refusal to participate in survey and loss to follow-up.

Source: 1994/1995 to 2008/2009 National Population Health Survey, longitudinal sample (square).



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Health of First Nations children living off reserve and Métis children younger than age 6

by Leanne Findlay and Teresa Janz

Abstract

Background

Aboriginal children have been shown to experience poorer health, compared with their non-Aboriginal counterparts. Differences in health status may be associated with family and social conditions, lifestyle or behaviour, and cultural factors.

Data and methods.

The current study examined the parent/guardian-reported health of First Nations children living off reserve and Métis children younger than 6. This does not include the 43% of First Nations children who were living on reserves in 2006. Data from the 2006 Aboriginal Children's Survey were used to investigate measures of child health and assess possible associations with social determinants of health.

Results

Most First Nations children living off reserve and Métis children were reported to be in excellent or very good health. The most common chronic conditions reported by parents/guardians were asthma, speech and language difficulties, allergies, and lactose intolerance. Several social determinants were associated with child health, including parental education, household income, breastfeeding, and perceptions of housing conditions and health facilities in the community.

Interpretation

The findings suggest that social factors can be associated with parent/guardian-rated health of First Nations children living off reserve and Métis children under age 6.

Keywords

Aboriginal, child health, chronic disease, indigenous, limitation of activity, social environment, socio-economic status

Authors

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Research has shown that Aboriginal children experience poorer health than do non-Aboriginal children.¹⁻³ For example, a recent report⁴ revealed substantial Aboriginal/non-Aboriginal health differences, including higher rates of injury, accidental death, and sudden infant death syndrome. Aboriginal children are at higher risk of otitis media (chronic ear infection), respiratory tract infections,⁵ obesity,⁶ dental problems,⁷ and hospitalization due to asthma.⁸

It has been suggested that the health differences between Aboriginal and non-Aboriginal populations are associated with social rather than biological determinants,⁹ many of which warrant further study for children specifically.^{4,10} Family and social conditions such as household income,⁸ parental education,¹¹ family structure,¹² smoking in the home,¹²⁻¹⁴ and food security¹⁵ have been found to be related to Aboriginal child health. Child health has also been linked to community characteristics, including housing^{16,17} and neighbourhood conditions.¹⁸

Cultural involvement and identity have been recognized as playing a role in the health and well-being of Aboriginal people,¹⁹ although little information is available about children. King et al.⁹ reported that traditional teachings are related to overall health and self-image, with ties to culture and identity being associated with good health.

Earlier studies, as well as Aboriginal groups and leaders, have recommended that rather than considering all Aboriginal peoples together, distinctions should be made between First Nations, Métis, and Inuit.¹⁰ And even comparisons between groups may be inadvisable, because they differ in cultural background, access to health care, and region of residence.

The current study examines parent-/guardian-reported data about the general health, chronic conditions and physical limitations of First Nations children living off reserve and Métis children younger than 6. The data are from the 2006 Aboriginal Children's Survey (ACS). Parent-/guardian-reported general health has been shown to be a good measure of overall child health.^{3,20} As well, this approach is consistent with previous research (for example, the First Nations Regional Health Survey) and is widely employed as a health surveillance tool.²¹

Methods

Data source

The 2006 ACS was developed by Statistics Canada and Aboriginal advisors from across the country. It was conducted jointly with Human Resources and Skills Development Canada. The survey was designed to provide data about children's early development and their social and living conditions.

The ACS target population consisted of First Nations children living off reserve, Métis children and Inuit children in the 10 provinces, as well as all Aboriginal children in the three territories. Children were identified on the ACS as "North American Indian"; however, the term "First Nations" is used throughout this report.

The sample of children younger than age 6 was selected from households with children identified by the 2006 Census as having Aboriginal ancestors; and/or identified as North American Indian and/or Métis and/or Inuit; and/or had treaty or registered Indian status; and/or had Indian Band membership. Children living on First Nation reserves were not included in the survey sample; thus, the results do not apply to the on-reserve population who accounted for an estimated 43% of First Nations people in 2006.²²

The overall response rate to the ACS was 81.1% ($n = 12,845$ children, representing a population of approximately 135,000 Aboriginal children younger than age 6). More information about the ACS is available elsewhere.²³ The current study pertains only to children whose parents reported that the children had single or multiple First Nations ($n = 5,167$) or Métis ($n = 3,793$) identity. Fewer than 2% of the population reported more than one Aboriginal group; therefore, only a small percentage of the population was doubled-counted.

Measures

Socio-demographic characteristics

The parent/guardian who responded to the ACS was the biological mother or

father for 90% of First Nations children living off reserve and 94% of Métis children. The parent/guardian provided information about the child's sex and age at the time of the interview, the parent's/guardian's educational attainment, the number of people in the household, total household income, the number of times the child had moved, and the province or region (Table 1). The parent/guardian also reported the number of people involved in raising the child (for example, father, grandparents, other family members), which was categorized as one, two, or three or more persons. The number of people raising the child was expected to be a more appropriate way of exploring family structure for Aboriginal children than the one-/two-parent dichotomy.²⁴

Because of small sample sizes, the Atlantic provinces (Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island) were grouped, as were the territories (Yukon, Northwest Territories, and Nunavut).

Information was collected on whether the child had been breastfed, and if so, the number of months.

Household food security was measured by the question: "How often has the child experienced being hungry because the family has run out of food or money to buy food?" Response options were: *more often than the end of each month, regularly at the end of the month, every few months, occasionally, and never*. For this study, food-insecure households were defined as those where the child experienced hunger because of food unavailability at least occasionally; the remaining households were defined as food-secure.

Information about smoking was collected with the question: "Including household members and regular visitors, does anyone smoke inside your home every day or almost every day?" (*yes, no*).

The child's level of activity was estimated from a question about the frequency of active play (*at least once per day, less than once per day, or never*). Total daily hours of screen time

(watching television and/or playing video games or computer use) was also reported.

The parent/guardian answered questions about satisfaction with their housing conditions (*very satisfied* or *satisfied* versus *dissatisfied* or *very dissatisfied*) and the community as a place with: i) health facilities, and ii) cultural activities (*excellent, very good, good* versus *fair, poor*).

Health indicators

As an overall marker of health, the parent/guardian reported the child's general health as: *excellent* or *very good* versus *good, fair* or *poor*. Other health outcomes were limitations on the child's physical activity due to a health condition (*yes, no*), the number of ear infections the child had in the past year, and whether the child had dental problems (*yes, no*). Only children aged 3 or older were included in the analysis of the dental questions, as the current recommendation is that children have regular dental check-ups by age 2 or 3. The parent/guardian reported the presence of chronic conditions, including asthma, allergies, visual/hearing impairment, heart conditions, diabetes, and Fetal Alcohol Disorder (Appendix A contains a list of chronic conditions included on the ACS). If a chronic condition was reported, the parent/guardian was asked if it had been diagnosed by a medical professional (*yes, no*). If the condition had been professionally diagnosed, the parent/guardian was asked if the child had received treatment for it (*yes, no*).

The prevalence of chronic conditions was examined to determine which occurred most frequently. Conditions with a prevalence rate of 5% or more were retained; remaining conditions were collapsed into an "other" category. Information about the prevalence of the specific conditions in the other category is available in Appendix A.

Statistical analyses

Bivariate statistics were used to describe the socio-demographic characteristics of the sample and the indicators of child

health. For some markers of health, information about non-Aboriginal children was available from the 2006 National Longitudinal Survey of Children and Youth. However, no statistical comparisons were made between Aboriginal and non-Aboriginal children because of differences in the sample and/or in the questions asked by the two surveys.

Within each Aboriginal group, chi-square comparisons and t-tests were calculated to identify socio-demographic and lifestyle characteristics significantly associated with excellent/very good versus good/fair/poor parent-/guardian-rated health. Self-rated health has been dichotomized this way in previous research,²⁵ in particular, with Aboriginal children,³ and was deemed appropriate because of the young age of this sample, the majority of whom would be expected to be in excellent/very good health.

Logistic regression analyses were performed predicting excellent/very good parent-/guardian-rated child health from the various social determinants. The purpose of these analyses was to determine which associations between child health and social determinants remained significant when the other determinants were also considered. Only variables significantly associated with the outcome variable at a univariate level (within Aboriginal groups) were included in the logistic regression models. Separate models were fitted for First Nations children living off reserve and Métis children.

Active play was excluded from the chi-square and regression analyses because of very little variation—almost all children were reported to engage in active play daily.

Survey sampling weights were used to ensure that all analyses were representative of the First Nations living off reserve and Métis populations in Canada. To account for the complex survey design, a bootstrapping technique was used for variance estimation,²⁶ and the appropriate multiplicative factor (the “Fay adjustment factor”) was applied.²³

Table 1

Selected characteristics of First Nations children living off reserve and Métis children younger than age 6, household population, Canada, 2006

	First Nations living off reserve (%) (n=5,167)	Métis (%) (n=3,793)
Sex		
Boys	50.7	51.8
Girls	49.3	48.2
Mean age in months (standard error)	39.5 (0.24)	39.7 (0.29)
Parent/Guardian education		
Less than secondary graduation	31.1	21.1
Secondary graduation or more	68.9	78.9
Number of people involved in raising child		
1	10.1	8.9
2	34.7	39.0
3 or more	55.2	52.1
Province/Territory		
Atlantic provinces	5.2	4.3
Québec	6.2	6.6
Ontario	26.3	17.6
Manitoba	13.3	19.5
Saskatchewan	12.7	14.0
Alberta	15.3	23.7
British Columbia	17.5	12.8
Yukon/Northwest Territories/Nunavut	3.6	1.6
Mean number of people in household (standard error)	4.3 (0.02)	4.2 (0.02)
Child breastfed		
Yes	72.3	74.6
No	27.7	25.4
Mean number of months child was breastfed (standard error)	7.9 (0.14)	7.3 (0.15)
Food-secure household		
Yes	94.9	97.4
No	5.1	2.6
Smoking		
Regular smoker in home	18.8	19.7
No regular smoker in home	81.2	80.4
Frequency of active play		
At least once per day	96.8	96.8
Less than once per day	2.2	2.1
Never	1.1	1.2 ^E
Mean daily hours of screen time (standard error)	2.6 (0.03)	2.4 (0.03)
Housing conditions		
Very satisfied/Satisfied	84.0	90.1
Dissatisfied/Very dissatisfied	16.0	10.0
Local health facilities		
Excellent/Very good/Good	79.0	79.8
Fair/Poor	21.0	20.2
Local cultural activities		
Excellent/Very good/Good	43.4	41.3
Fair/Poor	56.6	58.7

^E use with caution

Source: 2006 Aboriginal Children's Survey.

Results

First Nations children living off reserve

Health indicators

According to their parent/guardian, 85% of First Nations children younger than age 6 living off reserve were in excellent or very good health (Table 2). This compared with 90% of all Canadian children. Few First Nations children living off reserve (5%) were reported to have activity limitations due to a health condition. About half (51%) of First Nations children living off reserve had ever had an ear infection, and they averaged one infection in the past year. Of those aged 0 to 3, 46% (data not shown) of First Nations children living off reserve had had an ear infection, compared with 40% of all Canadian children in this age range.

Close to a third (30%) of First Nations children aged 3 or older living off reserve were reported to have had dental problems.

The most common chronic conditions among First Nations children living off reserve were asthma (10%), speech/language difficulties (10%), allergies (9%), and lactose intolerance (7%). One in six children (15%) had another chronic condition. However, not all children reported to have a chronic condition had been diagnosed by a health professional. For example, 70% of those with lactose intolerance, 76% with speech/language difficulties, 78% with allergies, and 95% with asthma had been professionally diagnosed. Of those who had been diagnosed, the prevalence of treatment varied from 57% for lactose intolerance to 96% for asthma.

Social determinants of health

The characteristics of First Nations children living off reserve who were in excellent/very good health differed from those of First Nations children living off reserve in good/fair/poor health (Table 3). Girls were significantly more likely than boys to be reported as being in excellent/very good health. The likelihood of excellent/very good health

Table 2

Health status of children, by Aboriginal identity, household population younger than age 6, Canada, 2006

	First Nations living off reserve (%)	Métis (%)	Total Canadian children (%) [†]
General health			
Excellent	59.6	63.0	64.6
Very good	25.1	24.5	25.8
Good	11.9	9.7	8.5
Fair	2.6	2.5	1.0
Poor	0.7 ^E	0.3 ^E	0.2 ^E
Physical activity limited by health condition			
Yes	4.6	3.9	..
No	95.4	96.1	..
Ever had ear infection			
Yes	50.5	51.4	40.1 [†]
No	49.5	48.6	59.9 [†]
Mean number of ear infections in past year (standard error)	1.3 (0.04)	1.2 (0.04)	..
Dental problems			
Yes	29.9	22.4	..
No	70.1	77.6	..
Chronic conditions			
Asthma	10.4	9.7	..
Of those who report, % diagnosed	94.6	95.9	7.8 [§]
Of those diagnosed, % received treatment	96.2	96.6	..
Speech/Language difficulties	10.2	9.3	..
Of those who report, % diagnosed	75.8	74.7	..
Of those diagnosed, % received treatment	82.2	81.2	..
Any allergies	9.1	10.4	..
Of those who report, % diagnosed	78.1	81.3	9.3 [§]
Of those diagnosed, % received treatment	65.9	62.1	..
Lactose intolerance	7.4	5.6	..
Of those who report, % diagnosed	69.9	71.8	..
Of those diagnosed, % received treatment	57.0	52.5	..
Other conditions	16.2	14.7	..
Of those who report, % diagnosed	86.8	87.4	..
Of those diagnosed, % received treatment	83.3	84.4	..

[†] based on 2006 National Longitudinal Survey of Children and Youth

[‡] aged 0 to 3

[§] diagnosed by health professional only

.. not available for specific reference period

^E use with caution

Sources: 2006 Aboriginal Children's Survey, 2006 National Longitudinal Survey of Children and Youth.

was significantly higher among children whose parent/guardian had graduated from secondary school, and among children raised by at least two people.

Geographic differences were also evident, with First Nations children living off reserve in the Atlantic provinces and Ontario significantly more likely to be in excellent/very good health than were those in the western provinces and the Territories. As well, children in Saskatchewan were less likely to be in excellent/very good health than were those in Quebec, Alberta or British

Columbia. Children in excellent/very good health tended to live in smaller households with a relatively high mean household income, and had moved fewer times ($t = 4.98$, $p < .001$) (data not shown because mean number of moves per year of age is not interpretable).

First Nations children living off reserve who had been breastfed were more likely to be in excellent/very good health than were those who had not been breastfed. The prevalence of excellent/very good health was also higher among

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Table 3

Social determinants of parent-/guardian-rated health status of First Nations children living off reserve and Métis children, household population younger than age 6, Canada, 2006

	Parent-/Guardian-rated health status							
	First Nations living off reserve				Métis			
	Excellent/ Very good (%)	Good/ Fair/ Poor (%)	Chi- square/ t-test	p-value	Excellent/ Very good (%)	Good/ Fair/ Poor (%)	Chi- square/ t-test	p-value
Sex								
Boys	83.6	16.4	4.99	<.05	85.7	14.3	7.54	<.01
Girls	86.0	14.0			88.9	11.1		
Age group								
0 to 23 months	84.7	15.3	0.47	ns	89.9 [†]	10.1	5.46	<.01
2 or 3 years	84.3	15.7			87.3	12.7		
4 or 5 years	85.4	14.6			85.5	14.5		
Parent/Guardian education								
Less than secondary graduation	80.1	19.9	29.47	<.0001	81.6	18.4	22.34	<.0001
Secondary graduation or more	87.0	13.0			88.9	11.1		
Number of people involved in raising child								
1	75.9 [‡]	24.1	11.13	<.0001	77.4 [‡]	22.6	9.87	<.0001
2	86.9	13.1			89.0	11.0		
3 or more	85.2	14.8			87.5	12.5		
Province/Territory								
Atlantic provinces	89.2 [§]	10.8 ^E	6.54	<.0001	90.3	9.7 ^E	3.77	<.001
Québec	86.9	13.1 ^E			88.6	11.4 ^E		
Ontario	89.3 [§]	10.7			87.8	12.2		
Manitoba	81.9	18.1			87.8	12.3		
Saskatchewan	79.0 ^{††}	21.0			80.0 ^{††}	20.0		
Alberta	83.8	16.2			89.9	10.1		
British Columbia	83.9	16.1			86.9	13.1		
Yukon/Northwest Territories/Nunavut	81.5	18.5			87.8	12.2 ^E		
Mean number of people in household (standard error)	4.3 (0.02)	4.7 (0.07)	-5.69	<.0001	4.1 (0.02)	4.2 (0.07)	-1.07	ns
Mean household income (standard error)	50,700 (711.0)	42,200 (1,146.6)	6.31	<.0001	61,600 (834.2)	44,500 (1,592.3)	9.70	<.0001
Child breastfed								
Yes	86.6	13.4	21.62	<.0001	88.9	11.1	16.67	<.0001
No	80.7	19.3			82.8	17.2		
Food-secure household								
Yes	85.4	14.7	9.84	<.01	87.5	12.5	3.93	<.05
No	76.3	23.7			79.0	21.0 ^E		
Smoking								
No regular smoker in home	85.7	14.3	7.16	<.01	88.5	11.5	11.76	<.0001
Regular smoker in home	81.6	18.4			82.7	17.4		
Mean daily hours of screen time (standard error)	2.6 (0.03)	2.6 (0.03)	-0.80	ns	2.4 (0.03)	2.6 (0.09)	-1.87	ns
Housing conditions								
Very satisfied/Satisfied	86.2	13.8	24.47	<.0001	88.2	11.8	14.48	<.0001
Dissatisfied/Very dissatisfied	77.7	22.3			79.4	20.6		
Community health facilities								
Excellent/Very good/Good	85.9	14.1	8.46	<.01	89.0	11.0	21.61	<.0001
Fair/Poor	81.9	18.1			81.4	18.6		
Community cultural activities								
Excellent/Very good/Good	85.1	14.9	0.00	ns	86.6	13.4	0.27	ns
Fair/Poor	85.0	15.0			87.3	12.7		

[†] significantly different from older children (p<0.05)

[‡] significantly different from 2 and from 3 or more (p<0.05)

[§] significantly different from Manitoba, Saskatchewan, Alberta, British Columbia and Yukon/Northwest Territories/Nunavut (p<0.05)

^{††} significantly different from Quebec, Alberta and British Columbia (p<0.05)

^{‡‡} significantly different from other provinces/territories (p<0.05)

^E use with caution

ns = not significant

Sources: 2006 Aboriginal Children's Survey, 2006 National Longitudinal Survey of Children and Youth.

children in food-secure households and in households where smoking did not occur regularly. Total daily screen time did not differ between children in excellent/very good health versus good/fair/poor health.

Parent/guardian satisfaction with housing conditions and positive perceptions of local health care facilities were associated with higher percentages of children being reported in excellent/very good health.

Of course, many characteristics that were associated with children's being in excellent/very good health are, themselves, interrelated. For example, it is not unreasonable to expect some association between parent/guardian education, household income and food security.

When the potential effects of these factors were controlled simultaneously in a logistic regression model, several remained independently and significantly related to the health of First Nations children living off reserve (Table 4). The odds of being reported in excellent/very good health were lower if the child was male and if one person (compared with two) was raising the child. The odds of excellent/very good health declined as household size and residential moves increased.

Children whose parent/guardian had at least secondary graduation (compared with lower attainment), who lived in a higher-income household, and who had been breastfed had significantly higher odds of excellent/very good health. The odds of excellent/very good health were also higher for children whose parent/guardian was very satisfied or satisfied with their housing (versus dissatisfied or very dissatisfied), and perceived community health care facilities to be excellent or very good (versus fair or poor).

Métis children

Health indicators

An estimated 87% of Métis children were reported by their parent or guardian to be in excellent or very good health (Table 2); for 4%, physical activity was limited by a health condition. Just over half

Table 4

Adjusted odds ratios relating social determinants to excellent/very good parent-/guardian-rated health, by Aboriginal identity, household population younger than age 6, Canada, 2006

	First Nations living off reserve (n=4,772)			Métis (n=3,606)		
	Adjusted odds ratio	95% confidence interval		Adjusted odds ratio	95% confidence interval	
		from	to		from	to
Sex						
Boys	0.8*	0.7	1.0	0.8*	0.6	1.0
Girls†	1.0	...	...	1.0	...	...
Age in months	§	...	...	1.0	1.0	1.0
Parent/Guardian education						
Less than secondary graduation†	1.0	...	...	1.0	...	...
Secondary graduation or more	1.2*	1.0	1.5	1.1	0.8	1.4
Number of people involved in raising child						
1	0.6*	0.4	0.8	0.6*	0.4	0.8
2†	1.0	...	...	1.0	...	...
3 or more	0.9	0.7	1.1	0.8	0.6	1.0
Household size‡	0.9*	0.8	0.9	§	...	...
Household income‡	1.1*	1.0	1.1	1.2*	1.1	1.3
Number of times child moved (per year of age)‡	0.9*	0.9	1.0	0.9*	0.9	1.0
Child breastfed						
Yes	1.5*	1.2	1.8	1.4*	1.1	1.8
No†	1.0	...	...	1.0	...	...
Food-secure household						
Yes†	1.0	...	...	1.0	...	...
No	0.7	0.5	1.1	0.8	0.4	1.3
Smoking						
Regular smoker in home	1.0	0.8	1.2	0.8	0.7	1.1
No regular smoker in home†	1.0	...	...	1.0	...	...
Housing conditions						
Very satisfied/Satisfied	1.4*	1.2	1.8	1.5*	1.1	2.0
Dissatisfied/Very dissatisfied†	1.0	...	...	1.0	...	...
Community health facilities						
Excellent/Very good/Good	1.3*	1.1	1.6	1.6*	1.3	2.1
Fair/Poor†	1.0	...	...	1.0	...	...

† reference category

‡ continuous variable

§ because of non-significant univariate results, predictor not included in model

* significantly different from reference category (p<0.05)

... not applicable

Source: 2006 Aboriginal Children's Survey.

(51%) of Métis children had had at least one ear infection in their lifetime (45% of those aged 3 or younger). Those who had ever had an ear infection experienced an average of one such infection in the past year. More than a fifth (22%) of Métis children aged 3 to 5 had had a dental problem in the past year.

The most common chronic conditions among Métis children were asthma (10%), allergies (10%), speech/language

difficulties (9%), and lactose intolerance (6%). One child in 6 (15%) had another chronic condition. Of those with a chronic condition, the percentage who had been diagnosed by a medical professional ranged from 72% (lactose intolerance) to 96% (asthma). And of those diagnosed, 53% with lactose intolerance, 62% with allergies, 81% with speech/language difficulties, and 97% with asthma had received treatment.

Social determinants of health

Girls and younger Métis children were more likely than boys and older children to be reported in excellent/very good health (Table 3). Higher educational attainment (secondary graduation or more) of the parent/guardian and being raised by two or more people (compared with one) were also associated with better health. Métis children in Saskatchewan were less likely to be reported as having excellent/very good health than were those elsewhere. Living in a higher-income household, experiencing relatively few residential moves ($t = -4.93, p < .001$), and having been breastfed were related to being in excellent/very good health (Table 3).

As well, children who lived in households that were food secure and where smoking in the home was not a regular occurrence were more likely to be in excellent/very good health. Screen time per day was not related to whether children were in excellent/very good versus good/fair/poor health. However, favourable parent-/guardian-reported perceptions of housing and community health facilities were associated with higher percentages of children in excellent/very good health.

When the social determinants of health were considered simultaneously (Table 4), several of them remained significantly related to the odds of Métis children being reported in excellent/very good health. Boys and children raised by one person (rather than two) had significantly lower odds of excellent/very good health. The odds of being in excellent/very good health declined as the number of residential moves increased. Children who were in higher-income households, who had been breastfed, and whose parent/guardian was very satisfied or satisfied with their housing and who perceived the community as having excellent, very good or good health facilities had higher odds of excellent/very good health than did children who did not share these characteristics.

Discussion

According to the 2006 Aboriginal Children's Survey, the majority of First Nations children living off reserve (85%) and Métis children (87%) younger than age 6 were reported to be in excellent or very good health by their parent or guardian. These percentages were lower than the 90% of all Canadian children in this health status category. These findings support previous work indicating health disparities for Aboriginal children.^{4,8}

The most common chronic conditions reported by parents/guardians of First Nations and Métis children were asthma, speech/language difficulties, allergies, and lactose intolerance. This is similar to results of the First Nations Regional Health Survey,³ which found asthma, allergies, and chronic ear infections to be the most common chronic conditions among First Nations children who lived on reserves. In the current study, the likelihood that these conditions had been professionally diagnosed and treated varied substantially, which may reflect differences in access to medical care or treatment options.^{4,27}

In the multivariate analysis, several social determinants were significantly associated with excellent/very good health for First Nations children living off reserve and Métis children: parent/guardian education, number of people involved in raising the child, household income, residential moves, and breastfeeding. By contrast, provincial differences in the prevalence of excellent/very good health at the univariate level disappeared in the multivariate models. This suggests that the effect of geography was mediated by/correlated with other variables included in the models.

Significant associations emerged between child health and the parent's/guardian's perceptions of the community. Even when the other family and social factors were taken into account, the odds that First Nations children living off reserve and Métis children would be reported in excellent/very good health were higher if the parent/guardian perceived housing conditions as excellent, very good or good. In

What is already known on this subject?

- Research has revealed disparities in the health of Aboriginal and non-Aboriginal children.
- It has been suggested that such differences stem from social rather than biological determinants.
- Much previous research examines Aboriginal peoples as a whole, although it has been recommended that studies focus on specific Aboriginal groups.

What does this study add?

- The current study uses parent-/guardian reported data to examine the health of children younger than age 6 who were identified as First Nations living off reserve or as Métis.
- More than 85% of the children in each group were reported to be in excellent or very good health.
- The most common chronic conditions reported by parents/guardians were asthma, speech and language difficulties, allergies, and lactose intolerance.
- Several social determinants of health were associated with child health, including parental education, household income, breastfeeding, perceived housing conditions, and community health care facilities.

addition, the odds of a favourable health rating were significantly higher for children whose parent/guardian perceived community health facilities to be excellent/very good/good rather than fair/poor. However, because the data are self-reported, a positive response bias is possible; that is, parents who rate their child's health positively may also be more likely to rate their housing and community health care facilities favourably.

Limitations and future directions

Despite numerous strengths of the current study, notably, the large and representative sample of Aboriginal children, several limitations should be noted. First Nations children who lived on reserves (43% of all First Nations children) were not included in the ACS; therefore, the findings cannot be generalized to that population. In addition, the measures were parent-reported and cross-sectional (taken at one time point). Longitudinal research, perhaps including multiple sources of data, is necessary to better understand the nature of the relationship between social conditions, health behaviours and health outcomes for Aboriginal children.

Nonetheless, the ACS parent/guardian ratings of general health are likely

valid measures. Preliminary analyses revealed an association between chronic conditions and general health—children with such conditions were more likely to be rated by their parent/guardian as being in poorer health, compared with children who did not have such conditions. However, future work could consider other indices of child health.

Finally, a cautionary note should be placed on the interpretation of “health.” Depending on the parent’s/guardian’s perceptions, the assessment of children’s health may or may not include mental health. Aboriginal peoples’ definition or interpretation of general health may be based on a holistic approach that encompasses physical, mental, emotional, and spiritual aspects.^{9,28,29} Thus, the measures of child health in

this analysis may not fully capture First Nations or Métis understanding of what constitutes health.

Conclusion

The current study provides evidence for associations between the health of Aboriginal children and several social determinants of health, including the number of people raising the child, breastfeeding, housing conditions, and perceptions of community health facilities. Future work is warranted to examine other markers and predictors of child health among First Nations living off reserve and Métis. ■

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Appendix

Table A
Prevalence of chronic conditions, diagnosis and treatment, by Aboriginal identity, household population younger than age 6, Canada, 2006

	First Nations living off reserve			Métis		
	%	Of those who report, % diagnosed	Of those diagnosed, % received treatment	%	Of those who report, % diagnosed	Of those diagnosed, % received treatment
Asthma	10.4	94.6	96.2	9.7	95.9	96.6
Speech/Language difficulties	10.2	75.8	82.2	9.3	74.7	81.2
Lactose intolerance	7.4	69.9	57.0	5.6	71.8	52.5
Food/Digestive allergies	3.8	74.0	67.6	3.9	73.4	62.0
Respiratory allergies	3.1	83.5	90.0	4.0	79.6	93.2
Other allergies	3.6	79.5	46.0	4.7	86.9	43.0
Visual impairment	2.5	93.9	88.1	2.6	97.0	85.3
Hearing impairment	2.0	87.6	79.2	1.6	85.3	88.8
ADD/ADHD	1.9	62.0	51.4	1.5	61.9	67.9
FAS/FASD	1.8	72.3	52.9	0.7 ^E	79.1	x
Heart condition or disease	1.7	93.7	36.8	2.1	99.3	45.6
Anaemia	1.7	93.9	97.2	1.4	93.5	91.1
Chronic bronchitis	1.6	89.5	92.5	1.5	79.7	100.0
Anxiety or depression	1.2	35.2 ^E	66.8	1.0 ^E	47.9 ^E	56.0 ^E
Kidney condition/Disease	0.7 ^E	94.5	81.4	0.6 ^E	100.0	68.0
Epilepsy	0.5 ^E	93.0	89.5	0.4 ^E	93.5	100.0
Autism	0.3 ^E	100.0	x	0.5 ^E	94.6	x
Cerebral palsy	0.3 ^E	100.0	100.0	x	x	x
Hypoglycemia/Low blood sugar	0.3 ^E	100.0	x	0.5 ^E	74.5	x
Tuberculosis	0.1 ^E	x	x	x	x	x
Diabetes	x	x	x	x	x	x
Down syndrome	x	x	x	x	x	x
Spina bifida	x	x	x	x	x	x

^E use with caution

x suppressed to meet confidentiality requirements of Statistics Act

Sources: 2006 Aboriginal Children's Survey.



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by Michelle Rotermann

Abstract

Based on data from the 2003 and 2009/2010 Canadian Community Health Survey (CCHS), this article provides current information about the sexual behaviours and condom use of 15- to 24-year-olds and examines changes since 2003. Between 2003 and 2009/2010, the percentage of 15- to 24-year-olds who had had sexual intercourse at least once remained stable, as did the percentages who reported becoming sexually active at an early age and having multiple sexual partners. Condom use increased between 2003 and 2009/2010, particularly among people reporting that they had just one sexual partner.

Key words

Adolescent behaviour, contraceptive behaviour, sexual intercourse, sexual partners

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Sexual behaviour is a major determinant of sexual and reproductive health.^{1,2} Early sexual intercourse, unprotected sex, and having multiple sexual partners put youth at risk of HIV and other sexually transmitted infections (STIs)³⁻⁶ and of unplanned pregnancy.^{7,8} Individuals aged 15 to 24 experience some of the highest rates of STIs.⁹⁻¹¹

Based on results of the 2003 and 2009/2010 Canadian Community Health Survey (CCHS), this article examines whether the sexual behaviour and condom use of 15- to 24-year-olds has changed since 2003 (the earliest years for which comparable national data are available).

Sexual activity

In 2009/2010, 66% of 15- to 24-year-olds reported having had sexual intercourse at least once, which was not significantly different from 2003 (data not shown). The likelihood of being sexually active rose with age. At ages 15 to 17, 30% reported having had sex, compared with 68% of 18- to 19-year-olds and 86% of 20- to 24-year-olds. The 2003 figures were 30%, 68%, and 85%, respectively (data not shown).

Early sexual intercourse

In 2009/2010, 9% of 15- to 24-year-olds reported that they first had sexual

intercourse when they were younger than 15, and about 25% had had intercourse for the first time at age 15 or 16 (Table 1). These results were not significantly different from 2003. However, in 2003, similar percentages of males and females reported having had intercourse before age 15, but in 2009/2010, this was less common among females (8%) than males (10%).

Multiple partners

In 2009/2010, about one-third of sexually active 15- to 24-year-olds reported having had sexual intercourse with more than one partner in the previous 12 months, unchanged from 2003 (Table 2). A larger percentage of sexually active males than females had had intercourse with more than one partner: 39% compared with 25%. The percentage reporting more than one sexual partner was higher among 15- to 17-year-olds than among 20- to 24-year-olds (35% versus 30%).

Table 1
Number and percentage of 15- to 24-year-olds who had first sexual intercourse before age 17, by sex, household population, Canada, 2003 and 2009/2010

Age at first intercourse	2003				2009/2010			
	Number '000	%	95% confidence interval		Number '000	%	95% confidence interval	
			from	to			from	to
Total								
Younger than 15	375.8	9.6	8.9	10.3	376.8	9.0	8.3	9.7
15 or 16	972.9	24.8	23.7	25.9	1,072.2	25.7	24.6	26.8
Sex								
Males								
Younger than 15	195.0	9.8	8.8	10.9	210.0	9.7	8.7	10.8
15 or 16	491.3	24.8	23.2	26.3	570.4	26.5	24.8	28.1
Females								
Younger than 15	180.8	9.3	8.4	10.3	166.8	8.2*	7.4	9.1
15 or 16	481.6	24.8	23.4	26.2	501.8	24.8	23.3	26.3

* significantly different from males younger than 15 ($p < 0.05$)

Note: Based on sexually active and inactive 15- to 24-year-olds.

Sources: 2003 and 2009/2010 Canadian Community Health Survey.

The percentages reporting multiple sexual partners were fairly consistent across the country. The exception was Yukon, where 54% of 15- to 24-year-olds reported having had intercourse with more than one partner in the past year, compared with the Canadian average of 32%. In Alberta, the percentage reporting multiple partners had been below the national figure in 2003, but by 2009/2010, the percentages were not significantly different.

Condom use

In 2009/10, 68% of sexually active 15- to 24-year olds reported using condoms the last time they had intercourse, compared with 62% in 2003 (Table 2). As in 2003, condom use was more common among

The data

Data from the 2003 and 2009/2010 Canadian Community Health Survey (CCHS) were used to estimate the prevalence of sexual activity, the number of sexual partners, and condom use among 15- to 24-year-olds. Data for the 2003 CCHS were collected from January through December. In 2007, the survey changed to continuous collection; the data for 2009/2010 were collected from January 2009 through December 2010. The response rate for 2003 was 81%, and for 2009/2010, 72%. Most interviews—70% in 2003 and 62% in 2009/2010—were by telephone. The samples used for the analyses in this article numbered 18,084 and 15,966 respondents aged 15 to 24, weighted to represent populations of approximately 4.2 million in 2003 and 4.4 million in 2009/2010. Details about the survey design and sampling techniques have been published elsewhere.¹²

All differences were tested to ensure statistical significance at the 0.05 level. To account for survey design effects, standard errors and coefficients of variation were estimated using the bootstrap technique.¹³

The percentage of 15- to 24-year-olds who had had sexual intercourse at least once was based on “yes/no” responses to the question, “Have you ever had sexual intercourse?”

Estimates of the percentages of 15- to 24-year-olds who became sexually active before age 15 or at ages 15 or 16 were calculated from responses to the question: “How old were you the first time?”

Respondents who reported ever having had sexual intercourse were asked, “In the past 12 months, have you had sexual intercourse?” Those who replied affirmatively were asked, “With how many different partners?”

Condom use was calculated among sexually active 15- to 24-year-olds who had been with multiple partners in the previous 12 months and/or who were not married or in a common-law relationship. The estimates were based on responses to: “Did you use a condom the last time you had intercourse?” Because condom use pertained to the most recent sexual encounter, it may not reflect typical behaviour. However, reports of condom use at the last sexual contact have been shown to approximate usual behaviour.¹⁴

The data about sexual behaviour in this article are self-reported, and so are subject to social desirability and recall biases. Social desirability is the tendency to modify answers to present a more favourable image. The impact of this phenomenon on estimates of sexual behaviour is difficult to quantify because the perception of what is “desirable” may differ depending on the respondent’s age, sex and socio-economic status. Some individuals may give socially acceptable answers (under-report) to questions about sexual behaviour; others may exaggerate their sexual experience. Establishing the veracity of reported sexual activity remains a challenge, as no universally accepted means of validation exists.¹⁵ However, studies that have used test-retest reliability methodology to verify self-reported sexual activity,^{16,17} condom use,¹⁸ and age of first sex¹⁷ find that adolescent reports are generally reliable. Moreover, the CCHS questions were developed through expert consultations and tested extensively to help ensure data accuracy and relevance.¹⁹

Because the CCHS is a household survey, the results can be generalized to the Canadian household population. This is an advantage over school-based surveys, which are often used to collect data about the sexual behaviour of young people, but which exclude youth no longer in school, a population that could be at high risk of contracting sexually transmitted infections and the Human Immunodeficiency Virus (STI/HIV).

Some information that would help to better understand the sexual habits of youth are not available on the CCHS, including relationship status and sexual partner characteristics. As well, the term “sexual intercourse” was not defined in the CCHS, so it is possible that some respondents may have misinterpreted the question.²⁰

Table 2

Multiple partners and condom use of sexually active 15- to 24-year olds, by sex, age group and province/territory, Canada, household population, 2003 and 2009/2010

Sex/Age group/ Province/Territory	Multiple partners in past year								Condom used at last sexual intercourse							
	2003				2009/2010				2003				2009/2010			
	Number '000	95% confidence interval			Number '000	95% confidence interval			Number '000	95% confidence interval			Number '000	95% confidence interval		
		%	from	to		%	from	to		%	from	to		%	from	to
Total	739.6	30.9	29.5	32.4	818.4	32.5	30.8	34.1	1,268.2	62.2	60.4	63.9	1,416.3	67.9 [†]	66.2	69.6
Sex																
Males [†]	436.0	36.7	34.4	38.9	508.6	39.0	36.7	41.3	720.0	67.3	64.8	69.8	817.4	72.5 [†]	70.2	74.7
Females	303.6	25.3*	23.5	27.0	309.8	25.4*	23.4	27.4	548.2	56.5*	54.1	58.9	598.9	62.5* [†]	60.1	65.0
Age group																
15 to 17 [†]	108.0	35.1	31.8	38.3	110.6	34.7	31.2	38.2	239.0	78.5	75.7	81.3	252.6	79.9	76.9	82.9
18 to 19	164.7	34.9	31.9	37.9	194.1	39.4	36.0	42.8	304.3	67.6*	64.7	70.4	349.3	73.7* [†]	70.8	76.7
20 to 24	466.9	29.0*	27.1	30.9	513.8	30.0*	28.0	32.1	725.0	56.4*	54.0	58.8	814.3	62.8* [†]	60.4	65.3
Province/Territory																
Newfoundland and Labrador	11.7	26.8	19.2	34.4	13.5	31.1	24.9	37.2	27.9	70.4*	63.0	77.8	25.9	70.0	62.4	77.7
Prince Edward Island	3.9	36.6	26.9	46.4	3.3	36.1	24.4	47.8	6.7	72.5	61.8	83.3	5.7	68.3	57.6	78.9
Nova Scotia	22.7	31.3	24.4	38.2	19.8	28.7	21.5	35.9	45.5	71.4	63.8	79.1	37.7	66.8	59.0	74.7
New Brunswick	19.0	31.5	24.8	38.3	17.5	33.2	27.1	39.3	31.6	61.1	53.7	68.6	30.1	73.1 [†]	66.2	80.0
Quebec	207.4	31.8	28.6	34.9	224.4	34.3	31.1	37.5	304.0	55.7*	51.9	59.6	326.0	59.9*	56.2	63.6
Ontario	273.7	31.0	28.5	33.5	275.3	30.4	27.6	33.2	504.9	65.1*	62.0	68.3	551.2	72.6* [†]	70.0	75.2
Manitoba	22.7	27.0	20.3	33.8	24.9	32.6	25.1	40.2	46.3	63.6	55.6	71.5	43.3	64.9*	57.8	72.1
Saskatchewan	20.4	28.7	23.5	33.9	25.7	32.3	26.7	37.9	37.9	66.1	59.3	72.9	42.3	68.9	62.0	75.8
Alberta	63.4	26.9*	23.3	30.5	113.3	34.8 [†]	29.9	39.6	112.1	59.6*	54.1	65.1	190.2	72.5* [†]	68.2	76.7
British Columbia	91.0	34.2	29.5	38.9	96.8	32.6	28.0	37.2	146.5	63.7	59.3	68.1	158.4	65.5	60.2	70.9
Yukon	1.0	39.0	25.4	52.5	1.5	54.0*	42.7	65.2	1.5	73.4	58.4	88.3	1.7	71.2	60.1	82.3
Northwest territories	1.6	38.2 [‡]	26.6	49.7	1.5	38.6	27.6	49.5	2.1	66.8	53.5	80.2	2.5	78.4*	69.2	87.7
Nunavut (10 largest communities [§])	0.9	36.4	26.8	46.0	0.9	36.6	26.5	46.8	1.2	72.7	54.9	90.6	1.4	79.1*	63.2	95.1

[†] reference category

* significantly different from reference category or from rest of Canada in same year ($p < 0.05$)

[‡] significantly different from 2003 ($p < 0.05$)

[§] Iqaluit, Cambridge Bay, Baker Lake, Arviat, Rankin Inlet, Kugluktuk, Pond Inlet, Cape Dorset, Pangnirtung, Igloodik

[‡] use with caution

Sources: 2003 and 2009/2010 Canadian Community Health Survey.

males than females—in 2009/2010, 73% of males, compared with 63% of females, reported using condoms the last time they had intercourse.

As was the case in 2003, the 2009/2010 results indicate that condom use declined with age from 80% among 15- to 17-year-olds to 63% among 20- to 24-year-olds (Table 2). This pattern prevailed among both sexes (data not shown). It may reflect the tendency to use other forms of birth control, such as oral contraceptives, at older ages.^{1,2,21} Furthermore, older individuals are more likely to be in longer-term, monogamous relationships in which partners perceive less risk of contracting HIV/STI and the use of condoms to be less important.²²⁻²⁴

In 2003, 15- to 24-year-olds with one sexual partner in the past year were less likely than those with more than one partner to report using a condom: 59% versus 68% (Table 3). By 2009/2010, the prevalence of condom use did not differ by the number of sexual partners: 67% (one partner) and 69% (more than one partner) (Table 3).

Regional differences

In 2009/2010, the prevalence of condom use was above the national average in Ontario (73%), Alberta (73%), Northwest Territories (78%) and Nunavut (79%), and below the average in Quebec (60%) and Manitoba (65%) (Table 3). In New Brunswick, Ontario and Alberta, the percentages reporting condom use

increased significantly between 2003 and 2009/2010. Condom use did not decline in any province or territory.

Geographic variations in condom use may reflect differences in the effectiveness of campaigns to promote their use²⁵ and in the accessibility and/or affordability of other contraceptives.^{23,25,26} In Quebec, for example, the province's drug insurance plan²⁷ reimburses the cost of some contraceptives, such as birth control pills.

Conclusion

According to self-reports to the 2009/2010 CCHS, two-thirds of 15- to 24-year-olds had had sexual intercourse at least once; a third of the age group had first done so when they were younger than 17. A

Table 3

Number and percentage of sexually active 15- to 24-year-olds who used condom at last sexual intercourse, by number of sexual partners in past year and age group, household population, Canada, 2003 and 2009/2010

	2003								2009/2010							
	One partner				Multiple partners				One partner				Multiple partners			
	Number '000	%	95% confidence interval		Number '000	%	95% confidence interval		Number '000	%	95% confidence interval		Number '000	%	95% confidence interval	
			from	to			from	to			from	to			from	to
Total	766.3	59.0	56.6	61.3	500.1	67.7*	65.1	70.2	850.5	67.2†	65.1	69.3	563.7	68.9	66.3	71.4
Age group																
15 to 17	154.9	78.9	75.2	82.2	84.0	77.8	72.8	82.1	166.7	81.2	77.3	84.6	85.6	77.5	72.2	82.0
18 to 19	190.9	66.8†	62.9	70.5	113.4	68.8†	64.2	73.1	202.8	72.7†‡	68.8	76.4	145.8	75.1‡	70.4	79.3
20 to 24	420.5	51.4†	48.1	54.7	302.7	65.0*†	61.2	68.5	481.0	61.6†‡	58.5	64.6	332.3	64.7†	61.0	68.3

* significantly different from individuals with one partner ($p < 0.05$)

† significantly different from 15- to 17-year-olds ($p < 0.05$)

‡ significantly different from 2003 ($p < 0.05$)

Sources: 2003 and 2009/2010 Canadian Community Health Survey.

third of those who were sexually active had had more than one partner in the past year. Condom use increased between 2003 and 2009/2010, particularly among people reporting just one sexual partner. Despite this increase, more than three in ten young adults did not use condoms the last time they had intercourse. Condom

use was lower than the national average in Quebec and Manitoba, and higher in Ontario, Alberta, Northwest Territories, and Nunavut. Surveys that collect data about the sexual behaviour and condom use of young adults remain important in informing and supporting health promotion and surveillance programs. ■

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Assessment of validity of self-reported smoking status

by Suzy L. Wong, Margot Shields, Scott Leatherdale, Eric Malaisson and David Hammond

Abstract

Background

Cigarette smoking is associated with adverse health effects, including cancer, respiratory illness, heart disease and stroke. National data on smoking prevalence often rely on self-reports. This study assesses the validity of self-reported cigarette smoking status among Canadians.

Data and methods

Data are from the 2007 to 2009 Canadian Health Measures Survey, a nationally representative cross-sectional survey of 4,530 Canadians aged 12 to 79. The survey included self-reported smoking status and a measure of urinary cotinine, a biomarker of exposure to tobacco smoke. The prevalence of cigarette smoking was calculated based on self-reports and also on urinary cotinine concentrations.

Results

Compared with estimates based on urinary cotinine concentration, smoking prevalence based on self-report was 0.3 percentage points lower. Sensitivity estimates (the percentage of respondents who reported being smokers among those classified as smokers based on cotinine concentrations) were similar for males and females (more than 90%). Although sensitivity tended to be lower for respondents aged 12 to 19 than for those aged 20 to 79, the difference did not attain statistical significance.

Interpretation

Accurate estimates of the prevalence of cigarette smoking among Canadians can be derived from self-reported smoking status data.

Keywords

Biological specimens, cotinine, data collection, direct measures, health surveys, reproducibility of results, urine specimen collection

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The health risks associated with cigarette smoking are well-documented and widely recognized—cancer, respiratory illness, heart disease, and stroke.¹⁻³ In Canada, smoking contributes to more than 37,000 deaths a year.⁴ Tobacco-related health care expenditures amount to billions of dollars annually, with additional indirect costs such as lost productivity, longer-term disability and premature death.⁴

Self-reported data are typically used to monitor trends in cigarette smoking.⁵⁻⁷ However, estimates based on self-report, particularly of socially undesirable behaviours, are subject to reporting biases.⁸ The widespread implementation of legislation prohibiting smoking in workplaces and public areas⁹ and prominent health warnings on cigarette packages may reinforce the perception of smoking as socially undesirable, and thereby increased the tendency to underreport over time.

To validate self-reported smoking status, the urinary concentration of cotinine, a widely accepted objective measure of exposure to tobacco smoke,¹⁰ has been used. Cotinine is the major metabolite of nicotine, with a half-life of about 16 to 20 hours.¹¹ Because of its

high sensitivity and specificity, cotinine is considered to be an accurate quantitative measure of recent exposure to tobacco smoke.¹² Compared with estimates based on cotinine concentration, smoking prevalence based on self-report, is generally lower,¹³ although the extent of the difference varies by country.¹⁴

The validity of self-reported cigarette smoking data have yet to be determined for Canada. Thus, this study compares estimates of the prevalence of cigarette smoking based on self-report with estimates based on urinary cotinine concentrations. The data are from the 2007 to 2009 Canadian Health Measures Survey, which included self-reported smoking status and the first nationally representative measures of urinary cotinine.

Methods

Data source

The Canadian Health Measures Survey (CHMS) is a nationally representative survey of the household population. Data for cycle 1 were collected from March 2007 through February 2009 at 15 sites across the country for respondents aged 6 to 79. Full-time members of the Canadian Forces and residents of Crown lands, Indian reserves, institutions and certain remote regions were excluded. The sample represented approximately 96% of the population.¹⁵

The CHMS consisted of a household interview during which information about socio-demographic characteristics, health and lifestyle was gathered. This was followed by a visit to a mobile examination centre where direct measurements, including the collection of urine samples, were taken.

Of the households selected for the survey, 69.6% agreed to participate. One or two members of each responding household were invited to take part in the survey. Of these, 88.3% responded to the household questionnaire, and 84.9% of those who completed the questionnaire visited the mobile examination centre. The overall response rate, after adjusting for the sampling strategy, was 51.7%. For adults aged 20 to 79, the overall response rate was 50.9%, and for youth aged 12 to 19, 52.7%. In total, 4,530 respondents aged 12 to 79 participated in the mobile examination centre component of the CHMS.

Ethics approval for conducting the CHMS was obtained from Health Canada's Research Ethics Board. Written informed consent was obtained from respondents. Participation was voluntary; respondents could opt out of any part of the survey at any time. Additional information about the survey is available in published reports¹⁶⁻²⁰ and on Statistics Canada's website (<http://www.statcan.gc.ca>).

During the household interview, respondents were asked if they currently smoked cigarettes daily, occasionally or not at all. They were also asked if they

had smoked cigars or a pipe or used snuff or chewing tobacco in the past month. To facilitate accurate reporting, when respondents aged 12 to 19 were being asked about sensitive topics including smoking, parents and guardians were requested to leave the room.

Respondents were asked if they had used prescription or over-the-counter medications in the past month. When they went to the mobile examination centre, they were asked to: confirm the medications they had previously reported; report any other medications they were taking; and report the last time they had taken each medication. Drug Identification Numbers (DIN) were collected for these medications and coded using the Anatomical Therapeutic Chemical (ATC) classification system. ATC code N07BA01 refers to medications in which nicotine is an active ingredient.²¹ This code would identify smoking cessation aids (nicotine patches, gums and aerosols) that contain nicotine as the active ingredient.

In the introduction to the household interview, respondents were told that direct measurements, including urine samples, would be taken at the mobile examination centre, and were given a list of the laboratory tests that would be performed. However, whether they were aware that the results of the cotinine test could be used to assess smoking status is unknown.

Urinary cotinine analysis

During each respondent's visit to the mobile examination centre (one day to six weeks after the household interview, an average of 13 days), a spot midstream urine sample was collected in a 120 ml container. The samples were frozen at -20 °C and shipped on dry ice to the testing laboratory at the Institut national de santé publique du Québec (accredited under ISO 17025). Free cotinine was recovered by solid-phase extraction in a 96 well plate format on an automated robotic workstation.²² Deuterated cotinine was used as the internal standard. The extract was then redissolved into 250 µL of mobile phase,

and 10 µL were injected into the ultra performance liquid chromatography-tandem mass spectrometric instrument, operated in the MRM mode with ion source in positive electrospray. The limit of detection was 1.1 µg/L. Details of the quality assurance program at the mobile examination centre and at the laboratory that performed the cotinine testing can be found elsewhere.²⁰

Statistical analysis

Certain exclusions were necessary to compare smoking status based on self-report versus urinary cotinine concentration. Respondents were excluded from the analyses if they:

- did not have a valid cotinine test result, for example, insufficient volume of urine collected; refused urine sample; etc. (n=48).
- reported using a medication with nicotine as an active ingredient (ATC code N07BA01) in the past month (n=4).
- reported smoking cigars or a pipe, or using snuff or chewing tobacco (n=258).

The latter two exclusions were necessary because it is possible that respondents who reported not being cigarette smokers could have been classified as smokers based on elevated cotinine concentrations that resulted from using these other nicotine-containing products. Among the 4,530 CHMS mobile examination centre participants aged 12 to 79, these exclusions resulted in a loss of 307 cases, leaving a final sample size of 4,223 for the study. (Three records were flagged for exclusion for more than one reason.)

For smoking status based on self-report, respondents who reported that they currently smoked cigarettes "daily" or "occasionally" were classified as smokers. For smoking status based on cotinine concentrations, respondents with urinary concentrations greater than 50 ng/ml were classified as smokers. This is the cut-point recommended by the Society for Research on Nicotine and Tobacco to distinguish tobacco users from non-tobacco users, including those

exposed to second-hand smoke.²³ It is highly unlikely that levels above this cut-point would be observed among non-users, even if they were regularly exposed to second-hand smoke.^{23,24}

The correlation between smoking prevalence based on self-report and cotinine concentrations was calculated. The accuracy of self-reported smoking status was assessed by calculating sensitivity and specificity. Sensitivity is the percentage of true positives (the percentage of respondents who reported being smokers among those classified as smokers based on cotinine concentrations). Specificity is the percent of true negatives (the percentage of respondents who reported being non-smokers among those classified as non-smokers based on cotinine concentrations).

Comparisons were made between the self-reported prevalence of smoking based on the CHMS and on other Statistics Canada surveys that collect data on smoking status. To make meaningful comparisons, it was necessary to calculate smoking prevalence for the entire CHMS sample (n=4,530) without the exclusions in the sensitivity and specificity analyses. CHMS smoking prevalence estimates based on the entire sample are shown in Appendix Table A.

Results are presented overall, by age group (12 to 19, 20 to 79), and by sex. Statistical analyses were performed using SAS and SUDAAN software. Standard errors, coefficients of variation and 95% confidence intervals were calculated with the bootstrap technique^{25,26} using the replicate weights provided on the datafile. The number of degrees of freedom was specified as 11 to account for the sample design.¹⁵ Differences between estimates were tested for statistical significance, established at the level of $p < 0.05$. Additional information on the CHMS measured cotinine levels, arithmetic mean, geometric mean and percentile distributions for urinary cotinine, overall, by age group and sex, for smokers and non-smokers, respectively, is available in a published report²⁷ and on the Health Canada website (<http://www.hc-sc.gc.ca>).

Results

Smoking prevalence: Self-report versus urinary cotinine

According to the CHMS, the prevalence of smoking was 18.8% based on self-report and 19.1% based on urinary cotinine concentration (Table 1). Differences between prevalences based on self-report versus cotinine concentration were not significant for any of the age/sex groups. Correlation results indicated strong agreement between smoking status based on self-report and cotinine ($r=0.90$, $p < 0.001$).

Accuracy of self-reported smoking status

Sensitivity for self-reported smoking status was 91.6% (Tables 2 and 3). That is, among respondents classified as smokers based on their urinary cotinine concentration, 91.6% reported that they were cigarette smokers, and 8.4% were misclassified in that they reported that they did not smoke cigarettes. The mean cotinine concentration for the misclassified cases was 615.7 ng/ml (95% CI: 427.5 to 803.8), which was substantially lower than the mean (1,239.4 [95% CI: 1100.2 to 1378.7]) for properly classified cases. Among the

Table 1
Prevalence of cigarette smoking based on self-report and urinary cotinine concentration, by sex and age group, household population aged 12 to 79, Canada, March 2007 to February 2009

Sex/Age group (years)	Self-report			Urinary cotinine concentration		
	%	95% confidence interval		%	95% confidence interval	
		from	to		from	to
Total	18.8	16.3	21.5	19.1	16.4	22.1
12 to 19	7.7 ^E	4.4	13.0	5.8 ^E	3.6	9.1
20 to 79	20.2	17.8	23.0	20.8	18.0	23.9
Male	19.0	15.8	22.7	19.2	15.8	23.1
12 to 19	5.4 ^E	3.1	9.4	4.5 ^E	2.3	8.4
20 to 79	20.9	17.5	24.7	21.2	17.6	25.4
Female	18.6	15.6	22.1	19.0	15.8	22.6
12 to 19	10.0 ^E	5.2	18.5	7.1 ^E	4.6	10.8
20 to 79	19.7	16.6	23.2	20.4	17.1	24.2

^E use with caution

Note: Excludes respondents who did not have a valid cotinine test result, reported using a medication with nicotine as an active ingredient in the past month, or reported smoking cigars or a pipe, or using snuff or chewing tobacco.

Source: 2007 to 2009 Canadian Health Measures Survey.

Table 2
Accuracy of classification of smoking status based on self-reports, household population aged 12 to 79, Canada, March 2007 to February 2009

Urinary cotinine concentration	Self-reported smoker			Self-reported non-smoker		
	%	95% confidence interval		%	95% confidence interval	
		from	to		from	to
Less than or equal to 50 ng/ml (non-smoker)	1.7	1.1	2.6	98.3	97.4	98.9
More than 50 ng/ml (smoker)	91.6	86.3	95.0	8.4	5.0	13.7

Note: Excludes respondents who did not have a valid cotinine test result, reported using a medication with nicotine as an active ingredient in the past month, or reported smoking cigars or a pipe, or using snuff or chewing tobacco.

Source: 2007 to 2009 Canadian Health Measures Survey.

Table 3
Sensitivity and specificity of self-reported smoking status, by sex and age group, household population aged 12 to 79, Canada, March 2007 to February 2009

Sex/Age group (years)	Sensitivity			Specificity		
	%	95% confidence interval		%	95% confidence interval	
		from	to		from	to
Total	91.6	86.3	95.0	98.3	97.4	98.9
12 to 19	81.6	56.5	93.8	96.9	94.0	98.4
20 to 79	92.0	86.3	95.4	98.6	97.8	99.1
Male	92.1	86.7	95.4	98.4	97.3	99.1
12 to 19	76.3	33.0	95.5	97.9	94.7	99.2
20 to 79	92.6	87.4	95.7	98.5	97.4	99.1
Female	91.2	84.4	95.1	98.3	96.9	99.0
12 to 19	85.0	53.3	96.6	95.8	89.6	98.3
20 to 79	91.4	83.9	95.6	98.6	97.6	99.2

Note: Excludes respondents who did not have a valid cotinine test result, reported using a medication with nicotine as an active ingredient in the past month, or reported smoking cigars or a pipe, or using snuff or chewing tobacco.

Source: 2007 to 2009 Canadian Health Measures Survey.

misclassified cases, a high percentage (74.7% [95% CI: 54.6 to 87.9]) reported that they were former cigarette smokers. The majority (60%) of these former smokers reported that they had quit during the past 5 years, and close to half (48%) reported they had quit in the past two years.

Sensitivity estimates were similar for males and females. And although sensitivity tended to be lower for respondents aged 12 to 19 than for those aged 20 to 79, the difference did not attain statistical significance.

Specificity for self-reported smoking status was 98.3%, meaning that 1.7% of respondents whose cotinine concentration classified them as non-smokers reported that they smoked cigarettes. Of these, the majority (89%) reported that they were occasional smokers. Most (82%) of these occasional smokers said they had smoked on 10 or fewer days in the past month, and about half (51%) reported they usually smoked only one cigarette on the days that they smoked.

Discussion

This study is the first to examine the validity of estimates of cigarette smoking prevalence in Canada based on self-report. Urinary cotinine concentration

measured by the CHMS provided a biomarker of tobacco smoke exposure with which to validate self-reported smoking status. The results indicated that smoking prevalence based on self-report closely approximates estimates based on cotinine concentration.

Smoking prevalence was 0.3 percentage points lower based on self-report than on cotinine concentrations. This was consistent with results from the United States where smoking prevalence was 0.6 percentage points lower when based on self-report than on cotinine concentration.¹⁴ In England and Poland, smoking prevalence based on self-report was lower by 2.8 percentage points and 4.4 percentage points, respectively.¹⁴ The strong correlation and lack of significant differences between smoking prevalence based on self-report and cotinine concentration in the present study suggest that self-reported data provide a valid estimate of national smoking prevalence in Canada.

Although sensitivity was high (91.6%), 8.4% of respondents were classified as “false negatives” (their cotinine concentrations identified them as smokers although they reported that they did not smoke). The mean cotinine concentration was substantially lower among these false negatives (615.7 ng/

ml) than among properly classified cases (1239.4 ng/ml), suggesting that heavy smokers are more likely than light smokers to report that they smoke.

Some misreporting would be expected due to social desirability bias. Although parents/guardians were asked to leave the room when the questions on smoking were administered to respondents aged 12 to 19, some of these younger respondents may have been reluctant to report that they smoked, resulting in the lower sensitivity estimates for this age group.

However, other reasons may explain some of the false negatives. Consistent with previous research,²⁸ a significantly higher percentage of the false negative cases reported being former smokers rather than never smokers, and the majority of these former smokers were recent quitters. Relapse is common among recent quitters.²⁹ If some of them relapsed in the period between their household interview and mobile examination centre visit, they would have been inappropriately classified as false negatives. Similarly, smoking initiation or experimentation in this period may have resulted in some cases being inappropriately classified as false negatives, particularly among respondents aged 12 to 19.

Other studies have found varying levels of sensitivity for self-reported estimates of smoking, depending on the population studied, the type of biological specimen used in the measurement of cotinine, and the cut-points used to identify smokers.¹³ Similar to the CHMS findings, sensitivity estimates greater than 90% have frequently been reported,¹³ but studies based on pregnant women,³⁰ and on patients with smoking-related illnesses such as respiratory disease³¹ and cancer³² have yielded lower estimates of sensitivity.

A small percentage (1.7%) of respondents were classified as “false positives” (their cotinine concentration classified them as non-smokers, but they reported that they smoked cigarettes). Nearly all these false positive cases reported that they were occasional

What is already known on this subject?

- Cigarette smoking is associated with adverse health effects, including cancer, respiratory illness, heart disease and stroke.
- National data on smoking prevalence data often rely on self-reports.
- The urinary concentration of cotinine is an objective measure of exposure to tobacco smoke.

What does this study add?

- Accurate estimates of the prevalence of cigarette smoking among Canadians can be derived from self-reported data on smoking status.

smokers, and most reported smoking on 10 or fewer days in the past month. Cotinine is a measure of recent exposure to tobacco smoke,²³ so it is likely that cotinine levels in some of these occasional smokers were too low to classify them as smokers.

An important question is the degree to which findings from this study apply to other Statistics Canada surveys that collect self-reported smoking data, such as the Canadian Community Health Survey (CCHS)⁶ and the Canadian Tobacco Use Monitoring Survey (CTUMS).³³ Survey respondents may be more likely to accurately report their smoking status if they know, or believe, that a biospecimen will also be collected to determine smoking status.³⁴ Unlike the CHMS, biospecimens are not collected by the CCHS or CTUMS.

According to the CHMS, 20% of Canadians aged 12 to 79 were self-reported smokers (Appendix Table A). The prevalence of self-reported smoking among people aged 12 or older from

the 2009 CCHS³⁵ was 20%. These similar results suggest that self-reported CCHS data provide accurate estimates of cigarette smoking prevalence.

In 2009, the prevalence of smoking estimated from CTUMS was 18% among the population aged 15 or older.³³ While trends in CTUMS data paralleled those derived from the CCHS, CTUMS smoking rates were consistently lower.⁵ However, unlike CTUMS, which is designed to monitor smoking prevalence, the smoking questions in the CCHS (and the CHMS) were asked in the context of a general health survey. A study of why smoking prevalence differs between the CCHS and CTUMS suggested that people are more inclined to talk frankly about smoking when the topic is part of a broad-based health survey.³⁶

The way in which data were collected might also contribute to differences in prevalence estimates between the surveys. CTUMS is conducted entirely by telephone; the CHMS is conducted entirely in person; and the CCHS uses in-person and telephone interviews. Nonetheless, a study comparing the effect of in-person and telephone interviews found that, overall, the interview mode was not associated with significantly different estimates of smoking prevalence.³⁷

Limitations

One limitation of this study was the relatively low overall CHMS response rate (52%). While the survey weights ensured that the sample was representative of the target population, bias might exist if non-respondents were more or less likely than respondents to be cigarette smokers and/or more or less likely to accurately self-report their smoking status. However, a comparison of the characteristics of those who responded to the household questionnaire with the characteristics of people who went on to complete the mobile examination centre component found the prevalence of smoking to be similar in the two groups.¹⁵ Furthermore,

smoking prevalence based on self-report was similar in the CHMS and the CCHS, the latter of which had a higher response rate (73%).⁶

The examination centre visit occurred, on average, 13 days after the household interview. Although the number of cases would likely be small, a true change in smoking behaviour during this interval may have resulted in some respondents being erroneously classified as false negatives or false positives.

The use of cotinine concentrations to assess the validity of self-reported smoking status may be inappropriate for occasional smokers and result in some respondents being erroneously classified as false positives.

Small sample sizes for respondents aged 12 to 19 resulted in estimates with high sampling variability. Therefore, results for this age group should be interpreted with caution. Possibly because of small sample sizes, the lower sensitivity for the younger age group did not attain statistical significance. As future CHMS cycles become available, it will be possible to augment the sample and produce estimates with higher reliability.

Conclusion

Representative data for the Canadian population showed no significant difference between national estimates of smoking prevalence based on self-report versus urinary cotinine concentration. This suggests that self-reported data on smoking status provide a valid estimate of the prevalence of smoking in Canada. ■

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Appendix

Table A
Prevalence of cigarette smoking based on self-report, by age group and sex, household population aged 12 to 79, Canada, March 2007 to February 2009

Age group	Total			Male			Female		
	%	95% confidence interval		%	95% confidence interval		%	95% confidence interval	
		from	to		from	to		from	to
Total	20.3	17.8	23.1	21.8	19.0	24.8	18.9	15.8	22.5
12 to 18	11.7 ^E	6.3	20.7	10.9 ^E	6.2	18.4	12.6 ^E	6.1	24.2
20 to 79	21.5	19.4	23.9	23.3	20.7	26.2	19.8	16.9	23.1

^E use with caution

Source: 2007 to 2009 Canadian Health Measures Survey.



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Geozones: An area-based method for analysis of health outcomes

by Paul A. Peters, Lisa N. Oliver and Gisèle M. Carrière

Abstract

Background

Administrative datasets often lack information about individual characteristics such as Aboriginal identity and income. However, these datasets frequently contain individual-level geographic information (such as postal codes). This paper explains the methodology for creating Geozones, which are area-based thresholds of population characteristics derived from census data, which can be used in the analysis of social or economic differences in health and health service utilization.

Data and methods

With aggregate 2006 Census information at the Dissemination Area level, population concentration and exposure for characteristics of interest are analysed using threshold tables and concentration curves. Examples are presented for the Aboriginal population and for income gradients.

Results

The patterns of concentration of First Nations people, Métis, and Inuit differ from those of non-Aboriginal people and between urban and rural areas. The spatial patterns of concentration and exposure by income gradients also differ.

Interpretation

The Geozones method is a relatively easy way of identifying areas with lower and higher concentrations of subgroups. Because it is ecological-based, Geozones has the inherent strengths and weaknesses of this approach.

Keywords

Aboriginal people, administrative data, concentration curves, ecological studies, geography, income quintiles, threshold tables

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Administrative datasets that contain information about health service use and events such as births and deaths are powerful tools in population health research. However, such datasets often lack information about health determinants (for example, income and education) and individual characteristics (for example, Aboriginal identity or country of birth), which can be important to understanding health disparities among and between certain groups. This article describes the Geozones methodology for calculating area-based thresholds of population characteristics derived from census results that can be applied to administrative data for use in the analysis of inequalities in health outcomes, health service use, or social characteristics.

Compared with individual-level measures, the advantages of area-based indicators are that they: consider the total population in a geographic area; yield statistically reliable and consistent estimates; detect differences between groups; and can be tracked over time and geographic location.¹ Area-based studies examining the relationship between neighbourhood income differentials and health outcomes in Canada have shown differences in injury, mortality, life expectancy, and potential years of

life lost.²⁻⁷ Geozones has been applied in previous analyses of geographic areas with high concentrations of immigrants,⁸ First Nations people,⁹⁻¹² and Inuit.^{13,14}

Geozones stems from residential segregation analysis and the calculation of threshold profiles of spatial concentration.^{15,16} The proportion of a population subgroup in a geographic area is compared with the rest of the population or with other population subgroups in the same area. The resulting threshold definitions can be

used for comparative analyses of areas with different levels of concentration of a particular characteristic.¹⁷

This article presents a guide to calculating Geozones, using the examples of concentration of the Aboriginal identity population and of income quintiles.

Methods

Geozones is based on population proportions and the comparison of different populations within specified areas, the results of which are used to create a typology of population concentration for a given level of geographic aggregation.

The first step is calculation of threshold tables for a specific subgroup and a comparison group at a given level of geographic aggregation. In Canada, Dissemination Area (DA), Census Tract or Census Subdivision levels are most commonly used.

In the second step, concentration curves are plotted to display the distribution of the subgroup across specified thresholds and to determine potential cut-points for low or high concentrations.¹⁸ These curves provide a visual representation of population concentrations, which aids in selecting an appropriate threshold quantile.

Third, based on examination of the threshold tables and concentration curves, the population is divided into quantiles (terciles, quintiles, deciles, etc.). This quantile definition is the basis of Geozones. The concentration ranges within the chosen quantile constitute a typology for comparing areas with different concentrations of the subgroup of interest.

Fourth, because the purpose of some analyses is to compare geographic areas with low or high percentages of a specific subgroup, quantile classification tables are created to determine appropriate cut-points.

Geographic unit of analysis

Selection of the geographic unit of analysis depends on the distribution of

the subgroup of interest and the overall area under consideration. The level of geographic aggregation that is chosen influences the interpretation of results. For example, smaller areas have the advantage of increased variation and potentially improved discernment of local concentration, but they are more likely to produce spurious associations.¹⁹ As well, difficulties achieving adequate population counts may make larger geographic units preferable.

This study uses DAs, which consist of one or more urban city blocks or rural areas with a population of 400 to 700.²⁰ The DA was selected because it has 100% coverage and is the smallest geographic unit for which census population and dwelling characteristics are disseminated.

In this article, census data by self-identification as North American Indian, Métis or Inuit and by income quintile are examined at the DA level. The term, “First Nations people,” is used to refer to census respondents who reported their identity as North American Indian. Income quintiles are based on average household income at the national level. Although DAs totalled 54,626 in 2006, this analysis is based on a somewhat smaller number—the 52,973 DAs for which the proportion of residents reporting Aboriginal identity or where a population large enough to calculate income quintiles was available. Aboriginal identity and income quintile could not be determined for DAs with fewer than 40 residents, for those with high global non-response, or for incompletely enumerated Indian Reserves.

Threshold tables

The threshold table method has been shown to be a robust means of comparing concentrations of subgroups at a regional level.^{17,21,22} It allows for the production of tables and maps showing where subgroups form a majority, are dominant (modal), or exceed defined concentration levels.¹⁷ It is also the first step in creating a typology, according to which areas are classified based on the proportion

of the subgroup of interest.¹⁶ The Geozones methodology described here uses the threshold profiles to compare health outcomes in areas with different concentrations of the subgroup.

For each subgroup of interest, the proportion it constitutes of the total population of each geographic unit (DA) is calculated. To measure *concentration* of that subgroup, the proportion living in geographic areas with a given percentage of the *same* group is calculated. By changing the denominator in this calculation, it is possible to measure the proportion of a subgroup that lives in geographic areas with a given percentage of a *different* subgroup, that is, the *exposure* of one subgroup to another.

Concentration curves

Concentration curves illustrate the proportion of subgroups in geographic areas by selected thresholds.²¹ Concentration curves are created by plotting each row of the threshold tables. These curves are a means of determining if the selected thresholds are valid, and if the geographic areas represent the subgroup of interest. Although this stage is not essential, simultaneously displaying coverage and concentration is helpful in understanding the subgroup under consideration.

Quantile definition

The quantile range influences the interpretation of results and depends on the descriptive or analytic model. The quantile definition categorizes geographic areas as having low versus high percentages of the subgroup. By definition, each quantile contains an equal percentage of the subgroup, but an unequal number of geographic areas (in this case, DAs).

Quantiles are calculated by ranking the geographic areas from those with the lowest to the highest percentage of the subgroup. The first category of geographic areas that contains the desired percentage (one-third, one-fifth, etc.) of the subgroup is coded 1, the second is coded 2, and so on until all geographic areas are coded based on the chosen

number of quantiles. Quintiles are used most often, although terciles, quartiles, etc. could be employed. Selection of the quantile may be constrained by the size of the subgroup and the frequency of the outcome under consideration (for instance, hospitalization or cancer incidence). Quantile selection may also be influenced by the characteristic or determinant under study. For individual characteristics such as Aboriginal identity, the purpose may be to compare areas with a low or high percentage, but for health determinants such as income or education, the purpose may be to examine the gradients of concentration.

Data preparation

Constructing Geozones requires careful preparation of the data. From an epidemiological perspective, it is essential that the entire population-at-risk be included in the analysis. Thus, ensuring an appropriate numerator and denominator is important. Health administrative data (numerators) with complete population coverage, such as death certificates, acute-care hospitalizations and cancer registry

statistics, should be coupled with denominators that also have complete population coverage—for example, area population counts by age and sex that include institutional residents.

Results

Aboriginal identity

Table 1 shows the threshold concentrations for the same-group population for all Aboriginal identity groups combined, First Nations people, Métis, Inuit, and non-Aboriginal people. Column headings indicate the percentage that the same-group population constitutes of the total DA population, by decile thresholds. Rows show the proportion of the group residing in DAs with the indicated percentage of the same-group population. For instance, in 2006, 38% of Aboriginal people lived in DAs where less than 10% of the population reported Aboriginal identity. However, another 26% of Aboriginal people lived in DAs where more than 90% of the population reported Aboriginal identity. By comparison, 95% of the non-Aboriginal population lived in DAs

where more than 90% of the population identified as non-Aboriginal. The differences in the concentration profiles of First Nations people, Métis and Inuit in Table 1 demonstrate the importance of studying each group separately.

When the degree of metropolitan influence is considered, a different picture emerges. In metropolitan-influenced zones, just 8% of the Aboriginal population lived in DAs where more than 90% of the population reported Aboriginal identity. By contrast, in non-metropolitan-influenced zones, 60% of the Aboriginal population lived in DAs where more than 90% of the population reported Aboriginal identity. The results differ among the three Aboriginal identity groups and for the non-Aboriginal population. For example, First Nations people were significantly more concentrated in non-metropolitan-influenced zones (70% lived in DAs where more than 90% of the population identified as First Nations people) than they were in metropolitan-influenced zones (13% lived in DAs where more than 90% of the population identified as First Nations people).

Table 1
Concentration of Aboriginal identity groups and non-Aboriginal population, by Dissemination Area (DA) decile threshold, metropolitan and non-metropolitan-influenced areas, Canada, 2006

Aboriginal identity and metropolitan influence	Dissemination Area (DA) decile threshold (%)									
	0 to 10	>10 to 20	>20 to 30	>30 to 40	>40 to 50	>50 to 60	>60 to 70	>70 to 80	>80 to 90	>90 to 100
Proportion of total DA population in same group										
All areas										
Total Aboriginal identity	0.38	0.16	0.07	0.04	0.02	0.02	0.01	0.01	0.02	0.26
First Nations	0.38	0.11	0.04	0.03	0.02	0.01	0.01	0.01	0.04	0.36
Métis	0.68	0.20	0.06	0.02	0.01	0.01	0.00	0.02	0.01	0.00
Inuit	0.17	0.02	0.02	0.02	0.02	0.05	0.01	0.06	0.14	0.50
Non-Aboriginal population	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.95
Metropolitan-influenced zones										
Total Aboriginal identity	0.52	0.21	0.08	0.04	0.02	0.02	0.01	0.01	0.01	0.08
First Nations	0.57	0.15	0.05	0.03	0.02	0.01	0.01	0.01	0.02	0.13
Métis	0.74	0.19	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Inuit	0.94	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Aboriginal population	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.96
Non-metropolitan-influenced zones										
Total Aboriginal identity	0.10	0.08	0.05	0.03	0.03	0.02	0.02	0.02	0.05	0.60
First Nations	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.06	0.70
Métis	0.43	0.25	0.13	0.05	0.02	0.03	0.01	0.07	0.02	0.00
Inuit	0.04	0.01	0.02	0.02	0.02	0.06	0.01	0.07	0.16	0.59
Non-Aboriginal population	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.10	0.84

> = more than

Source: 2006 Census of Population.

Table 2

Exposure of Aboriginal identity groups to non-Aboriginal population, by Dissemination Area (DA) decile threshold, metropolitan and non-metropolitan-influenced areas, Canada, 2006

Aboriginal identity and metropolitan influence	Percentage non-Aboriginal in DA population (%)									
	0 to 10	>10 to 20	>20 to 30	>30 to 40	>40 to 50	>50 to 60	>60 to 70	>70 to 80	>80 to 90	>90 to 100
Proportion of group in DA category										
All areas										
Total Aboriginal identity	0.26	0.02	0.01	0.02	0.02	0.02	0.04	0.07	0.16	0.38
First Nations	0.38	0.02	0.01	0.02	0.02	0.03	0.04	0.06	0.13	0.30
Métis	0.03	0.01	0.01	0.01	0.02	0.02	0.05	0.09	0.24	0.52
Inuit	0.56	0.12	0.03	0.04	0.04	0.01	0.02	0.02	0.04	0.11
Metropolitan-influenced zones										
Total Aboriginal identity	0.08	0.01	0.01	0.01	0.02	0.02	0.04	0.08	0.20	0.52
First Nations	0.14	0.02	0.01	0.02	0.02	0.03	0.04	0.08	0.18	0.47
Métis	0.01	0.00	0.00	0.01	0.01	0.02	0.04	0.09	0.24	0.58
Inuit	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.08	0.21	0.65
Non-metropolitan-influenced zones										
Total Aboriginal identity	0.60	0.05	0.02	0.02	0.02	0.03	0.03	0.05	0.08	0.10
First Nations	0.75	0.03	0.01	0.02	0.01	0.02	0.02	0.03	0.05	0.05
Métis	0.11	0.04	0.02	0.03	0.04	0.05	0.07	0.13	0.23	0.29
Inuit	0.66	0.14	0.04	0.05	0.05	0.02	0.02	0.01	0.01	0.01

> = more than

Source: 2006 Census of Population.

A change in the group column percentages shifts the focus from concentration to exposure—the extent to which subgroups live in areas with a specified percentage of another

population group. Table 2 shows the proportions of the Aboriginal identity groups living in areas with varying percentages of non-Aboriginal people. For instance, 56% of Inuit, but only 3%

of Métis, lived in DAs where fewer than 10% of the total population reported non-Aboriginal identity.

Table 3

Concentration of population, by household income quintile and Dissemination Area (DA) decile threshold, Canada, 2006

Household income quintile	Dissemination Area (DA) decile threshold (%)									
	0 to 10	>10 to 20	>20 to 30	>30 to 40	>40 to 50	>50 to 60	>60 to 70	>70 to 80	>80 to 90	>90 to 100
Proportion of total DA population in same household income quintile										
Q1 - lowest	0.10	0.22	0.21	0.16	0.12	0.09	0.06	0.03	0.01	0.00
Q2	0.06	0.26	0.35	0.22	0.08	0.02	0.00	0.00	0.00	0.00
Q3	0.05	0.27	0.39	0.21	0.06	0.01	0.00	0.00	0.00	0.00
Q4	0.05	0.24	0.38	0.23	0.07	0.02	0.00	0.00	0.00	0.00
Q5 - highest	0.07	0.18	0.21	0.19	0.15	0.10	0.05	0.03	0.01	0.00

> = more than

Source: 2006 Census of Population.

Table 4

Exposure of lower household income quintiles to highest household income quintile, by Dissemination Area (DA) decile threshold, Canada, 2006

Household income quintile	Highest household income group as percentage of total DA population (%)									
	0 to 10	>10 to 20	>20 to 30	>30 to 40	>40 to 50	>50 to 60	>60 to 70	>70 to 80	>80 to 90	>90 to 100
Proportion of quintile in DA category										
Q1 - lowest	0.55	0.23	0.12	0.06	0.03	0.01	0.00	0.00	0.00	0.00
Q2	0.43	0.28	0.15	0.08	0.04	0.01	0.01	0.00	0.00	0.00
Q3	0.34	0.29	0.18	0.10	0.05	0.02	0.01	0.00	0.00	0.00
Q4	0.25	0.27	0.21	0.14	0.08	0.04	0.01	0.00	0.00	0.00

> = more than

Source: 2006 Census of Population.

Income quintiles

Threshold tables were also constructed for concentration and exposure of the population by household income quintile.

Table 3 shows that people in the highest (Q5) and lowest (Q1) income quintiles were the most concentrated. For instance, 10% of people in the lowest household income quintile and 9% of those in the highest lived in DAs where more than 60% of the population were in the same quintile (the sum of the four columns covering >60% to 100%). Fewer than 1% of the population in the other three household income quintiles lived in DAs where more than 60% of the population were in the same quintile.

Table 4 shows the exposure of people in the first four household income quintiles (Q1 to Q4) to people in the highest (Q5). Just 1% of people in the lowest household income quintile (Q1) lived in DAs where at least 50% of the population were in the highest (Q5). In fact, more than half (55%) of those in the lowest income quintile (Q1) lived in DAs where a small percentage (less than 10%) of the population were in the highest income quintile (Q5). By comparison, 43% of people in Q2, 34% in Q3 and 25% in Q4 lived in DAs where less than 10% of the population were in the highest income quintile.

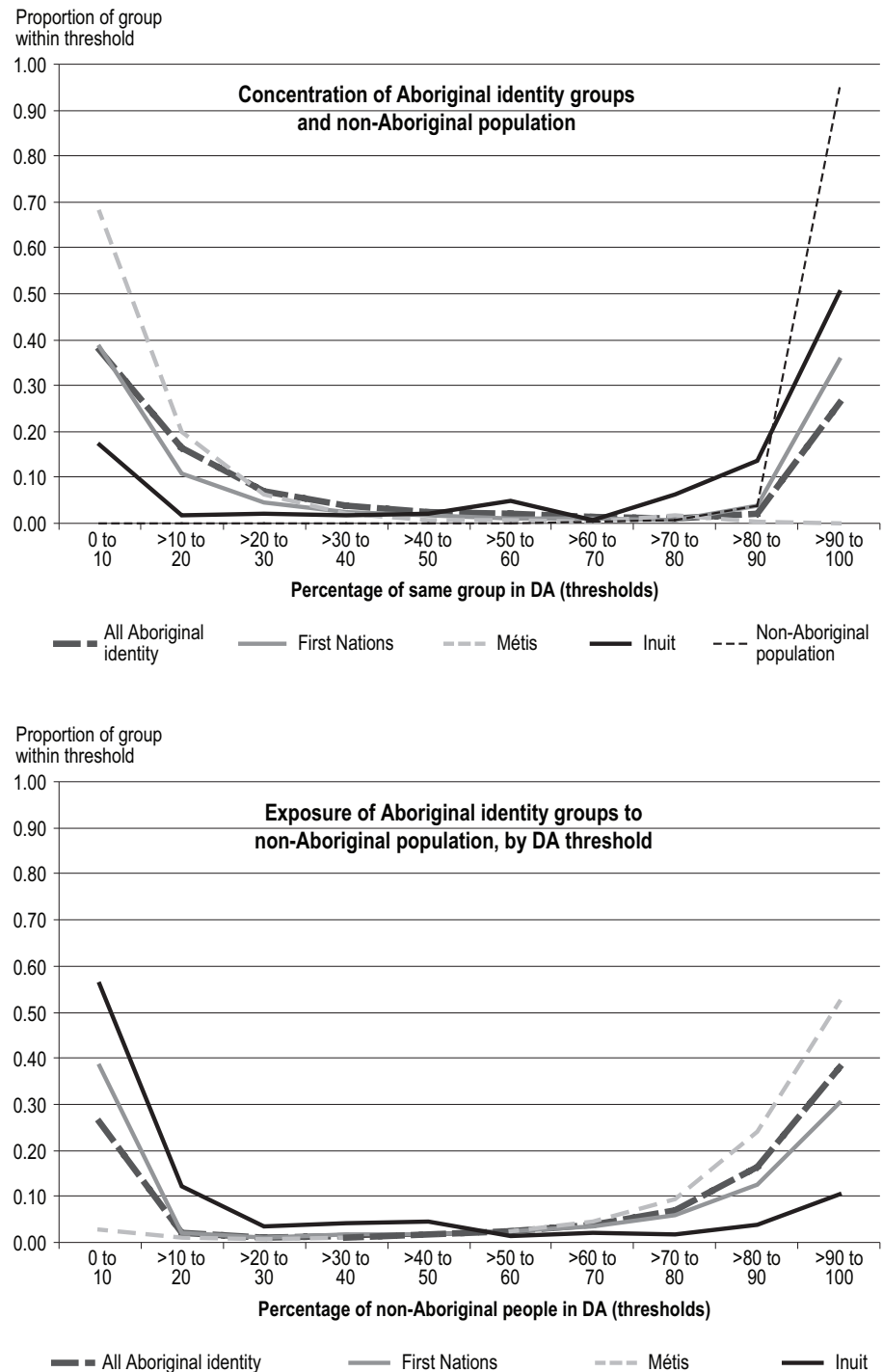
Plotting concentration and exposure

Based on the four threshold tables (Tables 1 to 4), concentration curves can be plotted for the various Aboriginal identity and household income groups.

The top panel in Figure 1 shows the concentration curve for the Aboriginal identity groups by the same-group thresholds at the DA level (first five rows of Table 1). A distinct U-shape is apparent in the distribution of First Nations people and Inuit, with large proportions either not concentrated (living in DAs with low percentages of the same group) or very concentrated (living in DAs with high percentages of the same group). This degree of concentration did not prevail for Métis, the majority of whom lived in DAs with

Figure 1

Concentration and exposure of Aboriginal identity groups and non-Aboriginal population, by Dissemination Area (DA) threshold, Canada, 2006



Source: 2006 Census of Population.

a low percentage of Métis residents. The non-Aboriginal population, on the other hand, was very concentrated—95% lived in DAs where more than 90% of the population was non-Aboriginal. The bottom panel in Figure 1 shows the exposure of Aboriginal identity groups to the non-Aboriginal population (first four rows of Table 2).

In Figure 2, the concentration and exposure of the population by household income quintile are shown by DA income thresholds. The top panel displays the concentration profiles of each household income quintile group (rows in Table 3), with people in the highest and lowest income quintiles more concentrated than those in the remaining quintiles. The bottom panel (rows in Table 4) shows that the people in the lowest household income quintile were less exposed to the population in the highest income quintile than were people in Q2, Q3 or Q4.

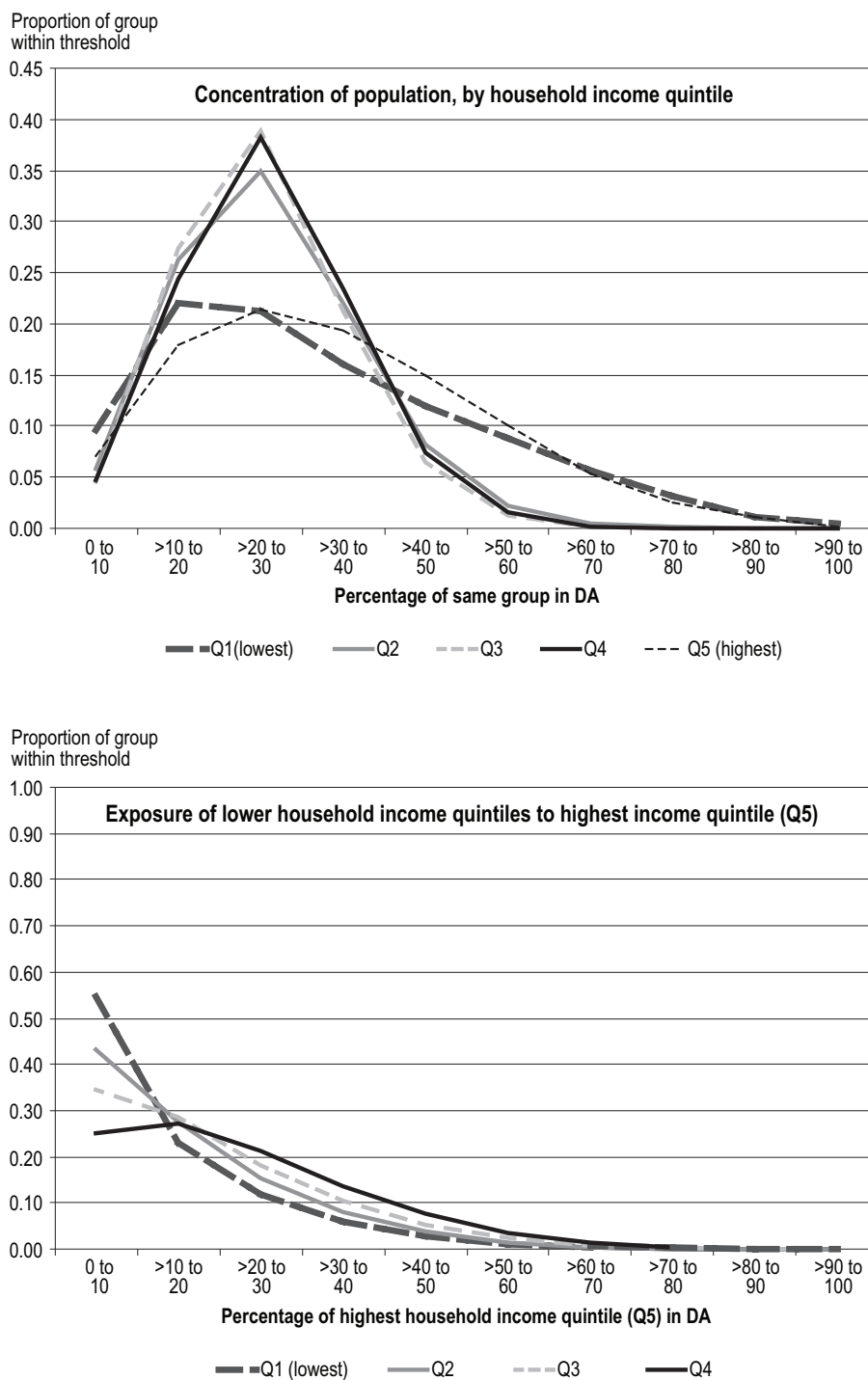
Figures 1 and 2 illustrate how the distributions of individual characteristics such as Aboriginal identity (concentration and exposure have a U-shaped distribution) differ from the distributions of health determinants such as income quintiles (concentration and exposure appear as a gradient).

Selecting cut-points

Table 5 shows a further step of quantile classification statistics—the threshold, coverage, and concentration of the population who reported Aboriginal identity. Each successive row increases the population threshold, decreases the coverage, and increases the concentration of the Aboriginal population. For instance, a threshold of 0.10 (1st decile) includes 20,114 DAs, where, collectively, 2% of the population reported Aboriginal identity (98% reported non-Aboriginal identity). By comparison, a threshold of 0.90 (10th decile) includes only 363 DAs, where, collectively, 98% of the population reported Aboriginal identity.

The data in this table can be used to select an appropriate cut-point for quantiles, where upper categories contain greater proportions of the subgroup. For instance, at the 0.80 threshold, 94%

Figure 2
Concentration and exposure of household income quintile groups, by Dissemination Area (DA) threshold, Canada, 2006



Source: 2006 Census of Population.

Table 5
Quintile classification statistics (vintiles), Aboriginal identity population, Canada 2006

Aboriginal identity proportion (vintiles)	Number of Dissemination Areas (DAs) with proportion of Aboriginal identity	Cumulative number of DAs with proportion of Aboriginal identity	Proportion of individuals with Aboriginal identity in selected DAs	Proportion of individuals with non-Aboriginal identity in selected DAs
0.00 (Total)	52,973	52,973	0.04	0.96
0.05	32,859	52,973	0.00	1.00
0.10	4,510	20,114	0.02	0.98
0.15	3,256	15,604	0.03	0.97
0.20	2,400	12,348	0.04	0.96
0.25	1,950	9,948	0.05	0.95
0.30	1,533	7,998	0.07	0.93
0.35	1,268	6,465	0.08	0.92
0.40	1,071	5,197	0.10	0.90
0.45	905	4,126	0.12	0.88
0.50	736	3,221	0.15	0.85
0.55	614	2,485	0.18	0.82
0.60	477	1,871	0.24	0.76
0.65	354	1,394	0.33	0.67
0.70	232	1,040	0.50	0.50
0.75	187	808	0.82	0.18
0.80	132	621	0.94	0.06
0.85	126	489	0.97	0.03
0.90	102	363	0.98	0.02
0.95	239	261	1.00	0.00
1.00	22	22	1.00	0.00

Source: 2006 Census of Population.

of the population reported Aboriginal identity. By comparison, at the 0.75 threshold, 82% of the population reported Aboriginal identity, and at the 0.70 threshold, 50%.

The definition for Aboriginal Geozones in this paper uses quintiles, where the 0.80 threshold corresponds to the highest quintile (94% of the population in these DA reported Aboriginal identity). Based on these results, Aboriginal identity quintiles can be mapped (Figure 3). At the national level, DAs in the 5th quintile (more than 80% of the population reported Aboriginal identity) were primarily located in rural areas, north of large urban centres, and largely in central and western parts of the country. DAs in the 4th quintile, which also had a large percentage of residents who reported Aboriginal identity (>60% to 80% of the population), were more common in urban areas. For instance, the distribution of Aboriginal DA quintiles in the Winnipeg urban area (Figure 4) shows strong concentration, with a cluster of DAs in the north of the city classified in the 4th quintile.

Limitations

Geozones treats each geographic unit as a discrete entity, and ignores the population composition of adjacent units. However, the administrative definition of units may not reflect differences in population composition, where a DA with a high percentage of a subgroup may be beside another DA with an equally high percentage of the same group. For example, the map of Winnipeg (Figure 4) shows considerable clustering of DAs with a high percentage of Aboriginal people. Therefore, some groups may be more or less concentrated than is suggested by the Geozones method, because aggregations of neighbouring DAs using different spatial configurations could change the level of concentration.

Inclusion of thresholds in linear models must be approached cautiously, as any unspecified spatial error may bias the results.²³ This can be accounted for by testing for the degree of spatial autocorrelation at local and global levels and including a spatial adjustment in the calculation.²⁴

Spatial methods of detecting local clusters, such as the Getis and Ord “hot-spots” or local Moran’s I, could also be used to identify concentrations of population groups. However, these techniques focus on the distribution of a population in a local area rather than on identifying specific geographic areas of concentration. Thus, the results would be complementary and could be used in combination with the Geozones methodology to gain further insight into the spatial distribution of a population.

Most Geozones calculations can use national population distributions to create concentration curves and thresholds.⁸ However, nationally derived thresholds may favour some parts of the country over others. For instance, thresholds for immigrants based on national distributions would exclude much of Atlantic Canada, despite concentrations of immigrants in some areas. Changing the method to include locale-specific population distributions would produce different thresholds for each area there. While this may benefit research focused

Figure 3
Dissemination Areas in upper (5th) Aboriginal quintile, Canada, 2006



Source: 2006 Census of Population.

on a specific sub-national geography (for example, Manitoba or Winnipeg), the results would not be nationally comparable.

Findings from analyses that use thresholds of First Nations, Métis or Inuit identity populations or ethnic minority groups cannot necessarily be generalized to the entire population of interest. Notably, the characteristics of the population in DAs where a high percentage of the population identifies as First Nations people, Métis or Inuit may differ from the characteristics of the population in DAs where the percentage of the local population with Aboriginal identity is low. Moreover, First Nations people, Métis and Inuit have different patterns of geographic

concentration, and thus, aggregation into a single Aboriginal category must be interpreted accordingly. In particular, the geographic concentration of Métis tends to be low, so this approach would likely yield an insufficient concentration of high-percentage Métis areas. By contrast, 78% of Inuit live in one of 53 communities in the Inuit Nunangat land claims settlement area.²⁵

Integration of health administrative data with thresholds calculated at the DA level requires accurate coding to census geographic codes. With tools such as the Postal Code Conversion File (PCCF+), administrative records containing postal codes can be automatically geo-coded with census and other administrative identifiers.²⁶

What is already known on the subject?

- Administrative datasets are powerful tools in population health research.
- Such datasets often lack information about health determinants such as income and education, and individual characteristics such as Aboriginal identity.
- The Geozones methodology for calculating area-based thresholds of population characteristics derived from census data can be applied to administrative files to analyze health outcomes and health service use.

What does this study add?

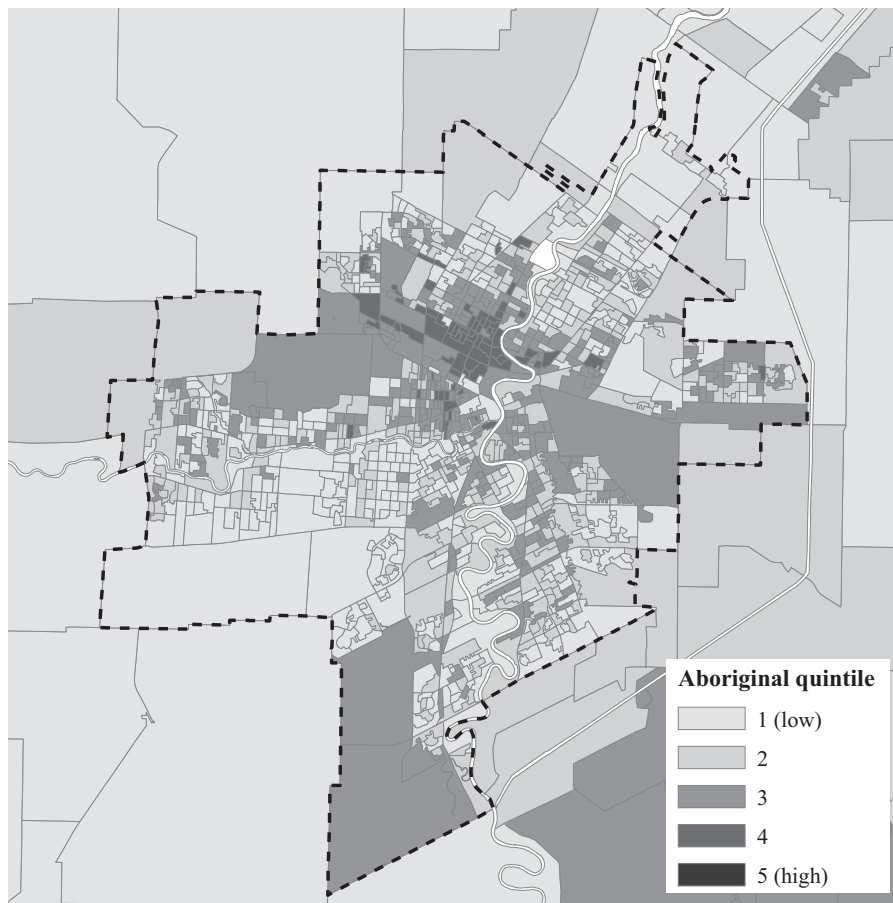
- This study presents a detailed and replicable methodology for the Geozones approach that combines that used for Aboriginal areas and for income gradients with the threshold table methodology widely used in geography literature.
- The methods can be applied to the analysis of health administrative data where sufficient concentrations of population subgroups exist.

Although not presented here, it is possible to calculate thresholds for multiple census years and track changes over time in the concentration of subgroups. Because geographic concentration may change significantly, analyses must use the appropriate threshold year and take potential changes in the underlying population into consideration.

Conclusion

Most health administrative databases in Canada do not contain socio-economic or ethnic identity information. Consequently, it is not possible to report on the health service use, morbidity, or mortality of population subgroups. However, geographic-based methods

Figure 4
Aboriginal quintiles, by Dissemination Area, Winnipeg urban area, 2006



Source: 2006 Census of Population.

can be used to obtain such information and analyze relationships between health outcomes, health services use and socio-economic characteristics for areas with high concentrations of these subgroups. The Geozones technique is a method of identifying areas with low or high concentrations of specific population characteristics and gradients of socio-economic determinants. ■

Acknowledgements

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