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Unintentional injury hospitalizations among children and youth in areas with a high percentage of Aboriginal identity residents: 2001/2002 to 2005/2006

by Lisa N. Oliver and Dafna E. Kohen

Abstract

Background
Because administrative data typically do not contain Aboriginal identifiers, national unintentional injury hospitalization rates among Aboriginal children have not been reported. This study examines rates of unintentional injury hospitalization for children in areas with a high-percentage Aboriginal identity population.

Data and Methods
Data are from the Hospital Morbidity Database (2001/2002 to 2005/2006). Rates of unintentional injury hospitalization were calculated for 0- to 19-year-olds in census Dissemination Areas (DAs) where at least 33% of residents reported an Aboriginal identity. DAs were classified as high-percentage First Nations, Métis or Inuit identity based on the predominant group.

Results
Unintentional injury hospitalization rates of children and youth in high-percentage Aboriginal identity areas were at least double the rate for their contemporaries in low-percentage Aboriginal identity areas. Falls and land transportation were the most common causes of unintentional injury hospitalization, regardless of Aboriginal identity status, but disparities between rates for high- and low-percentage Aboriginal identity areas were often greatest for less frequent causes, such as fire, natural/environmental, and drowning/suffocation.

Interpretation
The geographic areas where children live were associated with hospitalization rates for injury.

Keywords
Child health, drowning, hospital records, Inuit, Métis, poisoning, trauma

Authors
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Unintentional injury is the leading cause of death[1] and morbidity[2] among Canadian children. Not only are injuries associated with increased health care costs, hospitalizations and physician care,[3] but injuries sustained in childhood also have consequences that can last throughout the life-course.[4] For these reasons, childhood injuries have been identified as a public health issue. Among Aboriginal children, in particular, injury rates have been reported to be relatively high.[5-7]

Canadian studies of injury in Aboriginal populations have largely focused on adults.[8,9] Most studies of hospitalization due to injury have been restricted by the lack of Aboriginal identifiers on hospitalization records. To address this problem, some researchers have adopted a geographic approach and examined hospitalizations in areas that have a high percentage of Aboriginal residents.[10-12] These studies reported higher rates of injury hospitalization for people living in such areas.

While there are limitations to a geographic approach, the present analysis examines hospitalizations for unintentional injury among children and youth in communities where at least 33% of residents reported Aboriginal identity. The purposes are to: (1) calculate rates of unintentional injury hospitalization by cause for areas with a relatively high percentage of First Nations, Métis, and Inuit identity residents, and (2) compare those rates with rates for children and youth in areas with a low percentage of Aboriginal identity residents.

Methods

The data are from the 2001/2002 to 2005/2006 Hospital Morbidity Database (HMDB), which contains discharge records for all hospital separations in Canada. For each separation, information on the patient's age, sex, residential postal code, and diagnoses is available.

This analysis pertains only to acute-care facilities. The data represent the number of hospital separations, not

the number of individuals (a single individual may have been hospitalized more than once). Multiple diagnoses may be listed on discharge records; the presence of at least one diagnosis of unintentional injury made the record eligible for inclusion in this analysis.

Unintentional injuries are those for which there was no intent to harm; adverse effects due to drugs or medical care are excluded. The International Classification of Diseases (ICD) was used to classify unintentional injuries based on the external cause of the injury. The version of the ICD codes submitted by each province and recorded on the HMDB were used for this analysis. Causes of injury hospitalizations were grouped based on the International Collaborative Effort on Injury Statistics[13]: falls, land transportation, motor vehicle traffic (subset of land transportation), being struck, being cut/pierced, natural/environmental, poisoning, fire (includes hot substances), drowning/suffocation, and other.

Residential postal codes on individual hospital separation records were linked to census Dissemination Areas (DAs) via the Postal Code Conversion File.[14] Because discharge records for Quebec contain only the first three digits of the six-digit postal code, they were excluded from this study.

DAs where at least 33% of residents reported an Aboriginal identity to the 2001 Census were considered to be "high-percentage Aboriginal identity" areas.[10,15] These DAs were further classified as First Nations, Métis or Inuit identity areas, based on the *predominant* Aboriginal identity group in the DA. On average, predominant First Nations DAs had 76% First Nations identity; predominant Métis DAs, 38% Métis identity; and predominant Inuit DAs, 79% Inuit identity. All other DAs were designated low-percentage Aboriginal identity areas. Excluding Quebec, there were 1,862 predominant First Nations identity DAs, 135 predominant Métis identity DAs, 69 predominant Inuit identity DAs, and 38,774 low-percentage Aboriginal identity DAs.

The denominator for hospitalization rates was derived from the 2001 and 2006 Censuses. The denominator was the sum of the interpolated populations (aged 0 to 19) for each of the five years of hospitalization data (2001/2002 to 2005/2006, excluding Quebec) and was based on the midpoint (October) of the fiscal year (April to March). For the 2002/2003 fiscal year, Nunavut did not submit hospital separation data, and the population count for this year was excluded.

Because of small populations, global non-response, or incompletely enumerated Indian Reserves, a small number of DAs lacked the detailed age and sex data needed to provide a complete denominator. To retain these DAs in the sample, age and sex were estimated from total population counts or population estimates of incompletely enumerated Indian Reserves.

Valid cases of unintentional injury hospitalization for this analysis totalled 117,605. Because of invalid or missing postal codes, 3,320 unintentional injury hospitalizations were excluded, and another 327 were excluded owing to insufficient census information at the DA level.

Hospitalization rates were age-standardized to the Aboriginal identity population based on the 2001 Census. Age-standardized hospitalization rates (ASHRs) per 10,000 person-years at risk and rate ratios (RRs) for those in high-percentage First Nations, Métis and Inuit identity areas, compared with those in low-percentage Aboriginal identity areas, were calculated. ASHRs and RRs were calculated by sex, age group (0 to 9 and 10 to 19), and cause of injury. Confidence intervals were based

Table 1
Number and percentage distribution of hospitalizations for unintentional injury and crude rate, by sex, age group, Dissemination Area reporting Aboriginal identity, and cause of injury, population aged 0 to 19, Canada (excluding Quebec), 2001/2002 to 2005/2006

	Hospitalizations		Crude rate per 10,000 person-years at risk
	Number	%	
Total	**117,605**	**100.0**	**39.4**
Sex			
Male	77,960	66.3	50.9
Female	39,645	33.7	27.2
Age (years)			
0 to 9	46,954	39.9	33.9
10 to 19	70,651	60.1	44.1
Type of Dissemination Area			
High % First Nations	6,712	5.7	86.2
High % Métis	828	0.7	89.2
High % Inuit	546	0.5	83.3
Low % Aboriginal	109,519	93.1	37.8
Cause of injury†			
Falls	43,713	37.2	14.6
Land transportation	29,076	24.7	9.7
Motor vehicle traffic	13,842	11.8	4.6
Struck	13,400	11.4	4.5
Poisoning	6,647	5.7	2.2
Cut/Pierce	3,499	3.0	1.2
Fire	3,010	2.6	1.0
Natural/Environmental	2,920	2.5	1.0
Drowning/Suffocation	1,683	1.4	0.6
Other	14,524	12.3	4.9

† because multiple injuries were recorded, causes add to more than total
Notes: Dissemination Areas where at least 33% of the population reported Aboriginal identity are classified as high-percentage Aboriginal identity. Classification as high-percentage First Nations, Métis or Inuit identity is based on the predominant group.
Source: 2001/2002 to 2005/2006 Hospital Morbidity Database.

on a Poisson distribution. A t-test was used to determine if unintentional injury hospitalization rates for high-percentage First Nations, Métis, and Inuit identity areas differed significantly from rates for low-percentage Aboriginal identity areas ($p<0.05$). All statistical analyses were performed using SAS version 9.1.

Results

Hospitalization rates

From 2001/2002 through 2005/2006, Canadian hospitals (excluding Quebec) recorded 117,605 separations of children and youth aged 0 to 19 for unintentional injury (Table 1). Two-thirds of these hospitalizations were of males, and 60% were of 10- to 19-year-olds.

Overall, the crude unintentional injury hospitalization rate for the population aged 0 to 19 was 39.4 per 10,000 person-years at risk. Rates were considerably higher among children and youth in DAs where at least a third of the population reported Aboriginal identity: 86.2 per 10,000 person-years at risk in high-percentage First Nations identity areas; 89.2 in high-percentage Métis identity areas; and 83.3 in high-percentage Inuit identity areas.

When the rates were age-standardized to account for the different age distributions of each group, patterns were similar (Table 2). The age-standardized unintentional injury hospitalization rate (ASHR) for 0- to 19-year-olds was 37.1 per 10,000 person-years at risk in low-percentage Aboriginal identity areas, compared with 85.9 in high-percentage First Nations identity areas, 88.2 in high-percentage Métis identity areas, and 83.0 in high-percentage Inuit identity areas.

Rate ratios (RRs) were calculated to compare unintentional injury hospitalization rates in the three types of high-percentage Aboriginal identity areas with the rates for the low-percentage Aboriginal identity areas. RRs in the high-percentage Aboriginal identity areas ranged from 2.2 to 2.4; that is, ASHRs in these areas were more than twice those in low-percentage Aboriginal identity areas.

Table 2
Number of hospitalizations for unintentional injury, age-standardized rate, and rate ratio, by cause of injury and Dissemination Area reporting Aboriginal identity, population aged 0 to 19, Canada (excluding Quebec), 2001/2002 to 2005/2006

Cause of injury and type of Dissemination Area	Number	Age-standardized rate (per 10,000 person-years at risk)	95% confidence interval		Rate ratio	95% confidence interval	
			from	to		from	to
Total							
High % First Nations	6,712	85.9*	83.9	88.0	2.3	2.3	2.4
High % Métis	828	88.2*	82.4	94.5	2.4	2.2	2.6
High % Inuit	546	83.0*	76.3	90.3	2.2	2.1	2.4
Low % Aboriginal	109,519	37.1	36.8	37.3	1.0	...	...
Falls							
High % First Nations	2,223	28.7*	27.6	29.9	2.0	1.9	2.1
High % Métis	267	29.0*	25.7	32.7	2.0	1.8	2.3
High % Inuit	150	23.1*	19.7	27.1	1.6	1.4	1.9
Low % Aboriginal	41,073	14.4	14.3	14.5	1.0	...	...
Land transportation							
High % First Nations	1,694	21.5*	20.5	22.6	2.5	2.4	2.6
High % Métis	251	26.1*	23.0	29.5	3.0	2.7	3.4
High % Inuit	178	27.0*	23.3	31.3	3.1	2.7	3.6
Low % Aboriginal	26,953	8.6	8.5	8.7	1.0	...	...
Motor vehicle traffic							
High % First Nations	797	10.1*	9.4	10.8	2.5	2.3	2.7
High % Métis	88	9.0*	7.3	11.1	2.3	1.8	2.8
High % Inuit	59	8.9*	6.9	11.5	2.2	1.7	2.9
Low % Aboriginal	12,898	4.0	3.9	4.1	1.0	...	...
Struck							
High % First Nations	552	7.0*	6.5	7.7	1.7	1.6	1.9
High % Métis	81	8.5*	6.8	10.6	2.0	1.6	2.6
High % Inuit	40	6.1*	4.5	8.3	1.5	1.1	2.0
Low % Aboriginal	12,727	4.1	4.1	4.2	1.0	...	...
Poisoning							
High % First Nations	558	7.1*	6.5	7.7	3.3	3.1	3.6
High % Métis	44	4.9*	3.6	6.6	2.3	1.7	3.1
High % Inuit	31	4.6*	3.2	6.5	2.2	1.5	3.1
Low % Aboriginal	6,014	2.1	2.1	2.2	1.0	...	...
Cut/Pierce							
High % First Nations	251	3.2*	2.8	3.6	3.0	2.7	3.5
High % Métis	33	3.5*	2.5	5.0	3.4	2.4	4.8
High % Inuit	17	2.6*	1.6	4.2	2.5	1.5	4.0
Low % Aboriginal	3,198	1.0	1.0	1.1	1.0	...	...
Fire							
High % First Nations	305	3.9*	3.5	4.4	4.1	3.6	4.6
High % Métis	22	2.4*	1.6	3.7	2.5	1.7	3.9
High % Inuit	10	1.5	0.8	2.8	1.6	0.8	2.9
Low % Aboriginal	2,673	1.0	0.9	1.0	1.0	...	...
Natural/Environmental							
High % First Nations	265	3.4*	3.0	3.8	3.7	3.2	4.2
High % Métis	19	2.0*	1.3	3.2	2.2	1.4	3.5
High % Inuit	35	5.3*	3.8	7.4	5.8	4.1	8.1
Low % Aboriginal	2,601	0.9	0.9	1.0	1.0	...	...
Drowning/Suffocation							
High % First Nations	124	1.6*	1.3	1.9	2.8	2.3	3.3
High % Métis	15	1.7*	1.0	2.8	2.9	1.8	4.9
High % Inuit	11	1.7*	0.9	3.0	3.0	1.6	5.3
Low % Aboriginal	1,533	0.6	0.5	0.6	1.0	...	...
Other							
High % First Nations	784	10.0*	9.3	10.7	2.2	2.0	2.4
High % Métis	102	10.7*	8.8	13.0	2.3	1.9	2.8
High % Inuit	77	11.6*	9.3	14.5	2.5	2.0	3.2
Low % Aboriginal	13,561	4.6	4.5	4.7	1.0	...	...

* significantly different from low-percentage Aboriginal identity Dissemination Areas
... not applicable
Notes: Dissemination Areas where at least 33% of the population reported Aboriginal identity are classified as high-percentage Aboriginal identity. Classification as high-percentage First Nations, Métis or Inuit identity is based on the predominant group.
Source: 2001/2002 to 2005/2006 Hospital Morbidity Database.

Causes of injury

Almost without exception, ASHRs by cause of unintentional injury were significantly higher for children and youth in high-percentage First Nations, Métis, and Inuit identity areas than for their counterparts in low-percentage Aboriginal identity areas.

Falls ranked first as a cause of unintentional injury hospitalization among children and youth, whether they lived in high- or low-percentage Aboriginal identity DAs. This category includes falls on one level (for example, on ice) and falling off an object (for example, furniture). In high-percentage Aboriginal identity areas, ASHRs for injury due to falls ranged from 23.1 to 29.0 per 10,000 person-years at risk, compared with 14.4 in low-percentage Aboriginal identity areas.

Land transportation, the second most prevalent cause of unintentional injury hospitalizations among children and youth, involves motorized and non-motorized vehicles, on and off public highways. ASHRs exceeded 20.0 per 10,000 person-years at risk in high-percentage Aboriginal identity areas, compared with 8.6 in low-percentage Aboriginal identity areas.

ASHRs for unintentional injury due to each of the other causes were much lower, never surpassing 8.5 per 10,000 person-years at risk for children and youth in high-percentage Aboriginal identity areas, or 4.1 per 10,000 person-years at risk for those in low-percentage Aboriginal identity areas.

The higher ASHRs for unintentional injuries among children and youth in high-percentage Aboriginal identity areas are reflected in rate ratios (RRs). While overall RRs for unintentional injury hospitalization among those in high-percentage Aboriginal identity areas were a little more than 2.0, for some causes and for some high-percentage Aboriginal identity group areas, RRs approached or exceeded 3.0. This was the case for injuries due to land transportation (high-percentage Métis and Inuit identity areas) drowning/suffocation (all high-percentage Aboriginal identity areas), cut/pierce (high-percentage First Nations and Métis identity areas), and poisoning (high-percentage First Nations identity areas). Moreover, RRs for hospitalizations due to injury from fire and natural environmental causes were 4.1 and 3.7, respectively, for children and youth in high-percentage First Nations identity areas, and close to 6.0 for injuries related to natural/environmental causes in high-percentage Inuit areas.

Hospitalization rates vary by age group

ASHRs for total unintentional injuries varied by age group and were generally higher among 10- to 19-year-olds than among children aged 0 to 9. For example, in high-percentage Métis identity areas, the ASHR at ages 10 to 19 was 100.4 per 10,000 person-years at risk, compared with 76.9 at ages 0 to 9 (Table 3). In low-percentage Aboriginal identity areas, the corresponding rates were 42.2 and 32.2. However, this general pattern masks considerable age differences by cause of injury.

For unintentional injuries due to falls, poisoning, fire, natural/environmental causes and drowning/suffocation, ASHRs were higher at ages 0 to 9 than at ages 10 to 19. By contrast, ASHRs for unintentional injuries due to land transportation, being struck, and being cut/pierced were higher at ages 10 to 19.

At ages 0 to 9, RRs compared with children in low-percentage Aboriginal identity areas were particularly high (approximately 3.0) for injuries due to land transportation (high-percentage First Nations and Métis identity areas), poisoning (high-percentage First Nations identity areas), fire (high-percentage First Nations identity areas), natural environment (high-percentage First Nations and Inuit identity areas), and drowning/suffocation (high-percentage First Nations and Métis identity areas).

At ages 10 to 19, RRs in high-percentage First Nations identity areas were 3.0 or more for hospitalization for unintentional injuries due to poisoning, being cut/pierced, fire, and natural/environmental causes. RRs were also 3.0 or more for hospitalization for unintentional injury due to land transportation in high-percentage Métis and Inuit identity areas. As well, in high-percentage Inuit identity areas, the RR for hospitalization for unintentional injuries due to natural/environmental causes was 7.8.

Higher rate ratios for females

Regardless of whether an area was designated high- or low-percentage Aboriginal identity, ASHRs for unintentional injury were generally higher among males than females

What is already known on this subject?

- Unintentional injury is the leading cause of death and morbidity among Canadian children.
- Studies of injury in Aboriginal populations have tended to focus on adults.
- Little is known about injury hospitalization rates among Aboriginal children.

What does this study add?

- For most causes of unintentional injury, rates of hospitalization are higher for children and youth in areas with a high-percentage (33% or more) of Aboriginal identity residents, compared with those in low-percentage Aboriginal identity areas.
- Unintentional injury hospitalization rates for children and youth differed among high-percentage First Nations, Métis and Inuit identity areas.
- While hospitalization rates were higher among males, for many causes of unintentional injury, the disparity between high- and low-percentage Aboriginal identity areas was greater among females.

Table 3
Age-standardized hospitalization rate and rate ratio for unintentional injury, by age group, cause of injury and Dissemination Area reporting Aboriginal identity, population aged 0 to 19, Canada (excluding Quebec), 2001/2002 to 2005/2006

Cause of injury and type of Dissemination Area	Ages 0 to 9						Ages 10 to 19					
	Age-standardized rate (per 10,000 person-years at risk)	95% confidence interval		Rate ratio	95% confidence interval		Age-standardized rate (per 10,000 person-years at risk)	95% confidence interval		Rate ratio	95% confidence interval	
		from	to		from	to		from	to		from	to
Total												
High % First Nations	83.8*	81.0	86.7	2.6	2.5	2.7	88.2*	85.3	91.2	2.1	2.0	2.2
High % Métis	76.9*	69.2	85.4	2.4	2.1	2.7	100.4*	91.8	109.8	2.4	2.2	2.6
High % Inuit	66.7*	58.5	76.1	2.1	1.8	2.4	100.5*	90.1	112.0	2.4	2.1	2.7
Low % Aboriginal	32.2	31.9	32.5	1.0	...	...	42.2	41.9	42.6	1.0	...	...
Falls												
High % First Nations	33.9*	32.1	35.7	2.2	2.1	2.3	23.2*	21.7	24.8	1.7	1.6	1.9
High % Métis	33.1*	28.2	38.9	2.1	1.8	2.5	24.6*	20.5	29.5	1.9	1.5	2.2
High % Inuit	24.8*	20.0	30.8	1.6	1.3	2.0	21.2*	16.7	26.9	1.6	1.3	2.0
Low % Aboriginal	15.5	15.3	15.7	1.0	...	...	13.3	13.1	13.5	1.0	...	...
Land transportation												
High % First Nations	11.9*	10.8	13.0	3.0	2.7	3.3	31.9*	30.2	33.8	2.4	2.2	2.5
High % Métis	12.8*	9.9	16.6	3.2	2.5	4.2	40.3*	35.0	46.4	3.0	2.6	3.4
High % Inuit	10.1*	7.2	14.2	2.5	1.8	3.6	45.0*	38.3	53.0	3.3	2.8	3.9
Low % Aboriginal	4.0	3.9	4.1	1.0	...	...	13.5	13.3	13.7	1.0	...	...
Motor vehicle traffic												
High % First Nations	4.7*	4.1	5.5	2.9	2.5	3.4	15.8*	14.6	17.1	2.4	2.2	2.6
High % Métis	3.8*	2.3	6.0	2.3	1.4	3.8	14.7*	11.7	18.6	2.2	1.8	2.8
High % Inuit	3.4*	1.9	6.1	2.1	1.2	3.8	14.9*	11.2	19.8	2.3	1.7	3.0
Low % Aboriginal	1.6	1.5	1.7	1.0	...	...	6.6	6.4	6.7	1.0	...	...
Struck												
High % First Nations	4.9*	4.2	5.6	2.3	2.0	2.6	9.4*	8.5	10.4	1.5	1.3	1.7
High % Métis	4.9*	3.2	7.4	2.3	1.5	3.5	12.4*	9.6	16.0	2.0	1.5	2.5
High % Inuit	3.6	2.1	6.4	1.7	1.0	3.0	8.7	6.0	12.6	1.4	1.0	2.0
Low % Aboriginal	2.1	2.1	2.2	1.0	...	...	6.3	6.2	6.4	1.0	...	...
Poisoning												
High % First Nations	9.1*	8.2	10.1	3.4	3.1	3.8	4.9*	4.2	5.6	3.2	2.7	3.7
High % Métis	7.3*	5.2	10.3	2.7	1.9	3.9	2.3	1.3	4.1	1.5	0.8	2.7
High % Inuit	5.4*	3.5	8.5	2.0	1.3	3.2	3.7*	2.1	6.5	2.4	1.4	4.3
Low % Aboriginal	2.7	2.6	2.8	1.0	...	...	1.5	1.5	1.6	1.0	...	...
Cut/Pierce												
High % First Nations	2.0*	1.6	2.4	2.7	2.1	3.4	4.5*	3.9	5.2	3.3	2.8	3.8
High % Métis	3.3*	2.0	5.5	4.5	2.7	7.5	3.8*	2.4	6.0	2.7	1.7	4.4
High % Inuit	2.1*	1.0	4.4	2.8	1.3	6.0	3.1*	1.7	5.8	2.3	1.2	4.2
Low % Aboriginal	0.7	0.7	0.8	1.0	...	...	1.4	1.3	1.4	1.0	...	...
Fire												
High % First Nations	5.0*	4.4	5.8	3.9	3.4	4.5	2.7*	2.2	3.3	4.5	3.7	5.6
High % Métis	3.5*	2.2	5.8	2.7	1.7	4.5	1.3	0.6	2.8	2.1	0.9	4.7
High % Inuit	2.3	1.2	4.6	1.8	0.9	3.6	x	...	...	x	...	...
Low % Aboriginal	1.3	1.2	1.4	1.0	...	...	0.6	0.6	0.6	1.0	...	...
Natural/Environmental												
High % First Nations	4.2*	3.6	4.9	3.7	3.1	4.3	2.5*	2.1	3.1	3.7	3.0	4.6
High % Métis	2.2*	1.2	4.1	1.9	1.0	3.6	1.9*	1.0	3.6	2.7	1.4	5.3
High % Inuit	5.4*	3.4	8.5	4.7	2.9	7.4	5.3*	3.3	8.5	7.8	4.8	12.6
Low % Aboriginal	1.2	1.1	1.2	1.0	...	...	0.7	0.6	0.7	1.0	...	...
Drowning/Suffocation												
High % First Nations	2.8*	2.3	3.3	3.1	2.5	3.7	0.3	0.2	0.6	1.4	0.8	2.6
High % Métis	2.7*	1.5	4.7	2.9	1.7	5.2	x	...	...	x	...	...
High % Inuit	2.1*	1.0	4.4	2.3	1.1	4.9	x	...	...	x	...	...
Low % Aboriginal	0.9	0.9	1.0	1.0	...	...	0.2	0.2	0.2	1.0	...	...
Other												
High % First Nations	10.6*	9.6	11.6	2.6	2.3	2.8	9.4*	8.5	10.5	1.9	1.7	2.1
High % Métis	7.5*	5.4	10.5	1.8	1.3	2.6	14.2*	11.2	18.0	2.8	2.2	3.6
High % Inuit	10.8*	7.9	15.0	2.6	1.9	3.6	12.5*	9.1	17.0	2.5	1.8	3.4
Low % Aboriginal	4.1	4.0	4.2	1.0	...	...	5.1	5.0	5.2	1.0	...	...

* significantly different from low-percentage Aboriginal identity Dissemination Areas
... not applicable
x suppressed to meet confidentiality requirements of Statistics Act
Notes: Dissemination Areas where at least 33% of the population reported Aboriginal identity are classified as high-percentage Aboriginal identity. Classification as high-percentage First Nations, Métis or Inuit identity is based on the predominant group.
Source: 2001/2002 to 2005/2006 Hospital Morbidity Database.

Table 4
Age-standardized hospitalization rate and rate ratio for unintentional injury, by sex, cause of injury and Dissemination Area reporting Aboriginal identity, population aged 0 to 19, Canada (excluding Quebec), 2001/2002 to 2005/2006

Cause of injury and type of Disseminatin Area	Males						Females					
	Age-standardized rate (per 10,000 person-years at risk)	95% confidence interval		Rate ratio	95% confidence interval		Age-standardized rate (per 10,000 person-years at risk)	95% confidence interval		Rate ratio	95% confidence interval	
		from	to		from	to		from	to		from	to
Total												
High % First Nations	103.6*	100.5	106.8	2.2	2.1	2.2	67.4*	64.8	70.0	2.6	2.5	2.7
High % Métis	107.7*	98.8	117.4	2.3	2.1	2.5	68.3*	61.1	76.4	2.6	2.4	2.9
High % Inuit	103.6*	93.2	115.1	2.2	2.0	2.4	61.6*	53.6	70.8	2.4	2.1	2.7
Low % Aboriginal	47.6	47.2	47.9	1.0	...	...	26.0	25.7	26.2	1.0	...	...
Falls												
High % First Nations	34.1*	32.3	35.9	1.9	1.8	2.0	23.1*	21.6	24.7	2.1	2.0	2.3
High % Métis	35.3*	30.4	41.1	2.0	1.7	2.3	22.6*	18.5	27.5	2.1	1.7	2.6
High % Inuit	29.7*	24.3	36.2	1.7	1.4	2.0	16.3*	12.4	21.4	1.5	1.2	2.0
Low % Aboriginal	17.9	17.6	18.1	1.0	...	...	10.8	10.6	10.9	1.0	...	...
Land transportation												
High % First Nations	26.1*	24.5	27.7	2.3	2.1	2.4	16.8*	15.5	18.1	3.0	2.8	3.3
High % Métis	33.5*	28.8	39.1	2.9	2.5	3.4	18.4*	14.9	22.7	3.3	2.7	4.1
High % Inuit	32.5*	26.9	39.2	2.8	2.3	3.4	21.3*	16.8	27.0	3.8	3.0	4.8
Low % Aboriginal	11.5	11.3	11.6	1.0	...	...	5.6	5.5	5.7	1.0	...	...
Motor vehicle traffic												
High % First Nations	10.9*	9.9	11.9	2.3	2.1	2.5	9.2*	8.3	10.2	2.9	2.6	3.3
High % Métis	9.8*	7.4	13.0	2.0	1.5	2.7	8.3*	6.1	11.3	2.6	1.9	3.6
High % Inuit	9.5*	6.7	13.4	2.0	1.4	2.8	8.3*	5.7	12.2	2.6	1.8	3.9
Low % Aboriginal	4.8	4.7	4.9	1.0	...	...	3.2	3.1	3.2	1.0	...	...
Struck												
High % First Nations	10.4*	9.4	11.4	1.6	1.5	1.8	3.6*	3.0	4.2	1.9	1.6	2.3
High % Métis	11.7*	9.0	15.2	1.9	1.4	2.4	5.2*	3.5	7.8	2.8	1.9	4.2
High % Inuit	10.1*	7.2	14.1	1.6	1.1	2.2	1.9	0.8	4.2	1.0	0.5	2.3
Low % Aboriginal	6.3	6.2	6.4	1.0	...	...	1.9	1.8	1.9	1.0	...	...
Poisoning												
High % First Nations	6.7*	5.9	7.5	3.0	2.6	3.4	7.5*	6.7	8.4	3.8	3.4	4.3
High % Métis	4.2*	2.7	6.6	1.9	1.2	2.9	5.6*	3.8	8.2	2.8	1.9	4.2
High % Inuit	4.9*	3.1	7.9	2.2	1.4	3.5	4.2*	2.5	7.2	2.1	1.3	3.6
Low % Aboriginal	2.2	2.2	2.3	1.0	...	...	2.0	1.9	2.1	1.0	...	...
Cut/Pierce												
High % First Nations	4.7*	4.1	5.5	3.1	2.7	3.6	1.6*	1.2	2.0	2.9	2.2	3.7
High % Métis	5.0*	3.4	7.5	3.3	2.2	4.9	2.0*	1.0	3.9	3.7	1.9	7.2
High % Inuit	3.9*	2.3	6.7	2.6	1.5	4.4	x	...	...	x	...	...
Low % Aboriginal	1.5	1.5	1.6	1.0	...	...	0.5	0.5	0.6	1.0	...	...
Fire												
High % First Nations	5.1*	4.5	5.9	4.3	3.7	5.0	2.6*	2.2	3.2	3.7	3.0	4.5
High % Métis	2.6*	1.5	4.5	2.1	1.2	3.8	2.3*	1.3	4.3	3.3	1.7	6.1
High % Inuit	1.7	0.8	3.8	1.4	0.6	3.2	x	...	...	x	...	...
Low % Aboriginal	1.2	1.1	1.3	1.0	...	...	0.7	0.7	0.8	1.0	...	...
Natural/Environmental												
High % First Nations	3.9*	3.4	4.6	3.8	3.3	4.5	2.8*	2.3	3.4	3.4	2.8	4.2
High % Métis	2.3*	1.3	4.1	2.2	1.2	4.0	1.8*	0.9	3.6	2.2	1.1	4.4
High % Inuit	5.0*	3.1	8.1	4.9	3.0	7.9	5.6*	3.5	8.9	6.9	4.3	10.9
Low % Aboriginal	1.0	1.0	1.1	1.0	...	...	0.8	0.8	0.9	1.0	...	...
Drowning/Suffocation												
High % First Nations	1.7*	1.3	2.1	2.4	1.8	3.0	1.5*	1.1	1.9	3.5	2.7	4.6
High % Métis	1.3	0.6	2.8	1.8	0.8	4.0	2.1*	1.1	4.0	4.9	2.5	9.5
High % Inuit	1.8*	0.8	4.0	2.6	1.1	5.7	1.6*	0.6	3.7	3.6	1.5	8.8
Low % Aboriginal	0.7	0.7	0.8	1.0	...	...	0.4	0.4	0.5	1.0	...	...
Other												
High % First Nations	11.8*	10.7	12.9	2.1	1.9	2.3	8.2*	7.4	9.2	2.4	2.1	2.7
High % Métis	12.5*	9.7	16.0	2.2	1.7	2.8	9.0*	6.6	12.2	2.6	1.9	3.5
High % Inuit	14.5*	11.0	19.2	2.6	1.9	3.4	8.6*	5.9	12.5	2.5	1.7	3.6
Low % Aboriginal	5.6	5.5	5.8	1.0	...	...	3.5	3.4	3.6	1.0	...	...

* significantly different from low-percentage Aboriginal identity Dissemination Areas
... not applicable
x suppressed to meet confidentiality requirements of Statistics Act
Notes: Dissemination Areas where at least 33% of the population reported Aboriginal identity are classified as high-percentage Aboriginal identity. Classification as high-percentage First Nations, Métis or Inuit identity is based on the predominant group.
Source: 2001/2002 to 2005/2006 Hospital Morbidity Database.

(Table 4). Rate ratios, however, tended to be higher among females, indicating a greater difference compared with low-percentage Aboriginal areas. For instance, the RRs in high-percentage First Nations identity areas were 2.6 for females and 2.2 for males.

Rate ratios among females in high-percentage Aboriginal identity areas were particularly elevated (approximately 3.0 or more) for unintentional injury hospitalizations due to land transportation and drowning/suffocation. This was also the case for unintentional injury hospitalizations due to poisoning, cut/pierce, and fire in high-percentage First Nations and Métis identity areas, and due to natural/environmental causes in high-percentage First Nations and Inuit identity areas.

Discussion

This study reveals associations between the geographic areas where children and youth live and hospitalization for unintentional injury. Those in areas where at least 33% of residents reported Aboriginal identity were hospitalized at approximately twice the rate of their counterparts in low-percentage Aboriginal identity areas. Earlier studies based on provincial data[11,12,16] had similar results. For instance, First Nations children in Western Canada were reported to have injury hospitalization rates 1.2 to 2.9 times higher than those of the general population.[6] Similarly, First Nations children in Alberta were 1.4 times more likely to be hospitalized for an injury than were non-Aboriginal children.[16]

In the present analysis, ASHRs for injuries related to drowning/suffocation in high-percentage Aboriginal identity areas were approximately three times those in low-percentage Aboriginal identity areas. This is consistent with other research indicating that Aboriginal people are at increased risk of injuries due to drowning.[17] Even so, the overall ASHR for injuries due to drowning/suffocation was low, compared with causes such as falls and land transportation.

Unintentional injury hospitalization rates by cause differed among high-percentage First Nations, Métis and Inuit identity areas. ASHRs for injuries due to natural/environmental causes were highest in high-percentage Inuit identity areas, possibly reflecting conditions and activities specific to northern areas.[18] ASHRs for injuries due to fires were almost four times higher in high-percentage First Nations identity areas than in low-percentage Aboriginal identity areas, a finding consistent with earlier research.[6]

The RRs comparing unintentional injury hospitalizations in high- and low-percentage Aboriginal identity areas were often greater for females than males, a pattern reported in previous work.[11] Thus, although males were more likely to be hospitalized, the difference between residents of high- and low-Aboriginal identity areas was greater among females. In particular, RRs for females were greater for hospitalization for injuries due to poisoning and land transportation in high-percentage First Nations identity areas. Also, RRs for young children in high-percentage First Nations identity areas were greater than those for 10- to 19-year-olds for most causes of unintentional injury hospitalization.

Strengths and limitations

A strength of this study is the use of five years of national population-based data to examine rates and types of unintentional injury hospitalization for children and youth in high- and low-percentage Aboriginal identity areas, and the provision of breakdowns by injury type, age group and sex.

However, some limitations warrant discussion. Because Aboriginal identifiers were not available on the HMDB, a geographical proxy was used to designate census DAs as high- or low-percentage Aboriginal identity. Therefore, this is an ecological study reporting results for geographic areas; the associations observed do not necessarily apply at the individual level. As well, the geographic location where the injury occurred was not available.

A threshold of 33% was used to designate a DA as high-percentage Aboriginal identity.[10] For high-percentage Inuit identity areas, the 33% cut-off results in the selection of DAs with an average of 93% Aboriginal identity residents younger than age 20 (Appendix Table A). For high-percentage First Nations and Métis identity areas, the 33% cut-off results in the selection of DAs with 86% and 67% Aboriginal identity residents younger than age 20.[19] (A higher cut-point would have resulted in a substantial loss of high-percentage Métis identity areas.) Consequently, the findings are not representative of the First Nations, Métis, or Inuit identity populations in Canada.

High-percentage First Nations, Métis, and Inuit identity areas defined in this study differ in urban/rural location, population size, and socio-economic characteristics—all factors that have been associated with injury rates.[19,20] For example, 100% of the population living in high-percentage Inuit identity DAs were in weak or non-Metropolitan-Influenced zones, compared with 8% of the population in low-percentage Aboriginal identity DAs (Appendix Table A). Similarly, 27% of the population in high-percentage Inuit identity DAs lived in crowded dwellings, compared with 3% of the population in low-percentage Aboriginal identity areas. Also, information about individual and family characteristics such as income, education, and individual behaviours that may influence injury risk was not available on hospital records.

Previous research has found that injuries sustained among First Nations populations tend to be more severe.[8,12] Although the injuries included in this analysis were serious enough to result in hospitalization, the severity of those injuries was not assessed. And of course, injuries so severe that they resulted in death before hospital admission were not included in this analysis.

The results do not represent the entire country. Incomplete postal code

information for Quebec meant that the province had to be excluded from the study.

Finally, counts for some causes of injury for some Aboriginal identity groups were small.

Conclusion

Elevated rates of unintentional injury hospitalization among children and youth in high-percentage Aboriginal identity areas, compared with those in low-percentage Aboriginal identity areas, prevailed for all causes of injury examined in this analysis. While falls and land transportation injury hospitalizations were the most common, regardless of Aboriginal identity status, disparities between hospitalization rates for high- and low-percentage Aboriginal identity areas were often greatest for less frequent causes such as fire, natural/environmental causes, and drowning/suffocation. The extent of the difference in unintentional injury hospitalizations between high- and low-percentage Aboriginal identity areas varied, depending on whether the comparison was with high-percentage First Nations, Métis or Inuit identity areas. ■

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Appendix

Table A
Demographic and socio-economic census characteristics, by Aboriginal identity group in Dissemination Area, Canada (excluding Quebec), 2001

Characteristics	Low % Aboriginal	High % First Nations	High % Métis	High % Inuit
Total population	**19,137,200**	**338,500**	**49,000**	**31,800**
Aboriginal identity population (%)	3	77	57	87
Population aged 0 to 19 (%)	30	45	41	48
Population aged 0 to 19 of Aboriginal identity (%)	4	86	67	93
Population in weak or non-Metropolitan-Influenced Zone (%)	8	66	70	100
Population without secondary graduation (%)	30	53	45	52
Population not in labour force (%)	30	42	31	33
Population living in crowded dwellings (%)	3	21	10	27
Population in dwellings in need of major repair (%)	8	32	20	23
Average household income per person ($)	26,381	12,878	16,737	21,123

Notes: Dissemination Areas where at least 33% of the population reported Aboriginal identity are classified as high-percentage Aboriginal identity. Classification as high-percentage First Nations, Métis or Inuit is based on the predominant group.
Source: 2001 Census of Canada.

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Mortality rates among children and teenagers living in Inuit Nunangat, 1994 to 2008

by Lisa N. Oliver, Paul A. Peters and Dafna E. Kohen

Abstract

Background
Because Vital Statistics data do not include information on Inuit identity in all jurisdictions, mortality rates cannot be calculated specifically for Inuit. However, Inuit in Canada are geographically concentrated—78% live in Inuit Nunangat, and 82% of the area's total population identify as Inuit. While there are limitations, geographic approaches can be employed to calculate mortality for the population of that area.

Data and methods
The Vital Statistics Database (1994 to 2008) and population estimates were used to calculate age-standardized mortality rates (ASMRs) in five-year intervals around the 1996 and 2006 Census years. Mortality rates were calculated for 1- to 19-year-olds living in Inuit Nunangat and those living elsewhere in Canada.

Results
The ASMR in 2004-2008 for 1- to 19-year-olds in Inuit Nunangat was 188.0 deaths per 100,000 person-years at risk, five times the rate (35.3) elsewhere in Canada. The disparity had not narrowed over the previous decade. In Inuit Nunangat, injuries were responsible for 64% of deaths of children and teenagers, compared with 36% in the rest of Canada.

Interpretation
The persistently high mortality rates for children and teenagers living in Inuit Nunangat, compared with the rest of Canada, are important in understanding the health and socio-economic situation of residents of this region.

Keywords
Aboriginal, age-standardized mortality rates, child health, death rates, suicide, vital statistics, wounds and injuries

Authors
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A number of recent studies have examined life expectancy, mortality, hospitalization, and other health indicators for the four Inuit Nunangat land claim regions.[1-5] Life expectancy at birth for residents of that area is 6 to 11 years less than for people in the rest of Canada,[3,5] and the infant mortality rate is higher.[5,6] To date, child and youth mortality rates for residents of Inuit Nunangat have not been calculated.

Because Vital Statistics data do not include information on Inuit identity in all jurisdictions, mortality rates cannot be calculated specifically for Inuit. However, Inuit in Canada are geographically concentrated—78% live in Inuit Nunangat, and 82% of the area's total population identify as Inuit (Table 1). While there are limitations, geographic approaches can be employed to calculate mortality for the population of that area.

Inuit Nunangat is the Inuktitut term for "Inuit homeland," an expanse comprising more than one-third of Canada's land mass, which extends from northern Labrador to the Northwest Territories. It consists of the four Inuit land claim regions: Nunatsiavut (Northern coastal Labrador), Nunavik (Northern Quebec), the territory of Nunavut, and the Inuvialuit Settlement Region (Northwest Territories and Yukon).

The population of Inuit Nunangat is fast-growing and young. Between 1996 and 2006, the population of the area rose by 14%, compared with an 8% increase in the rest of Canada (Table 1). The primary driver of the increase in Inuit Nunangat was high growth among Inuit, at 18%. The result was a much younger population age structure than that of most other populations in Canada.[7] In 2006, 42% of the population in Inuit Nunangat were aged 1 to 19, compared with 24% of the population elsewhere in Canada.

This study examines disparities[8] in mortality between 1- to 19-year-old residents of Inuit Nunangat and the rest of Canada from 1994 to 2008. Mortality rates are calculated by cause of death.

Table 1
Total, non-Aboriginal and Inuit population, by residence, Canada, 2006

	Outside Inuit Nunangat	Inuit Nunangat	Inuit subregions: Inuvialuit Settlement Region	Nunavut	Nunavik	Nunatsiavut
Total population	30,071,225	48,015	5,705	29,325	10,570	2,415
% aged 1 to 19	24	42	34	43	45	36
% change since 1996	8	14	-2	19	21	-14
Non-Aboriginal	30,060,225	7,065	1,520	4,410	920	215
% of total population	96	15	26	15	9	9
% aged 1 to 19	23	15	18	16	11	12
% change since 1996	8	4	-4	11	-2	-28
Inuit	11,000	39,475	3,115	24,635	9,565	2,160
% Inuit	0	82	54	84	89	89
% aged 1 to 19	39	47	40	47	48	39
% change since 1996	62	18	-3	20	25	3

Source: 2006 Census of Population.

Methods

A geographic approach was employed to estimate mortality rates for children and teenagers in Inuit Nunangat and in the rest of Canada. A similar technique has been used to examine life expectancy, mortality, hospitalization, cancer incidence, and crime in this region.[1,5,9] Deaths of children younger than age 1 are considered to be infant mortality, and so are not included in this analysis.

A large majority (92%) of the population aged 1 to 19 in Inuit Nunangat identified as Inuit on the 2006 Census (data not shown). At more than 96%, Nunavik and Nunatsiavut had the highest percentages reporting Inuit identity; 65% of the population aged 1 to 19 in the Inuvialuit Region reported Inuit identity.

Each death record in the Vital Statistics Deaths Database contains the decedent's sex, age and usual place of residence (Census Subdivision - CSD). A single underlying cause of death is recorded, based on the International Classification of Diseases 9th (1994 to 1999) and 10th (2000 onwards) revisions (ICD-9 and ICD-10).

The analyses in this study are based on records for people who were aged 1 to 19 when they died. It excludes deaths of non-residents of Canada, deaths of residents of Canada whose province or territory of residence was unknown, and death records lacking the decedent's age or sex. The approach used for this analysis required that death records include geographic identifiers. For the Inuvialuit Region and Nunatsiavut, the complete CSD code was necessary; for Nunavik, either the CSD or Census Division code was needed; and for Nunavut, only the territory code.

The underlying causes of death, based on ICD-9 or ICD-10 codes, were grouped according to the Global Burden of Disease (GBD) classification.[10] The GBD framework differs from the ICD chapters, which categorize diseases by body systems. According to the GBD classification, deaths fall into three main groups: I - communicable, maternal, perinatal, and nutritional conditions; II - non-communicable diseases; and III - injuries. Groups I and II are further classified into specific diseases or conditions. Group III is subdivided into unintentional or intentional injuries and then classified by type. Because self-inflicted injury (suicide) accounted for nearly the entire intentional injury category in this study, for reasons of confidentiality, homicide could not be reported separately. Additional information on the GBD classification, the ICD-9 and ICD-10 codes, and the use of the GBD in Inuit Nunangat is available elsewhere.[10,11]

Small-area population estimates were used to provide detailed counts of those aged 1 to 19 for each CSD in Inuit Nunangat from 1996 through 2006.[12] These estimates are more accurate than those available on the census. The closest population estimates available were used as a proxy. Person-years at risk were calculated by aggregating the five years surrounding each census year (1996 and 2006).

Age-standardized mortality rates (ASMRs) (deaths per 100,000 person-years at risk) were calculated using the method of Chiang[13] in five-year intervals around the 1996 and 2006 Census years (1994 to 1998 and 2004 to 2008) in order to obtain the minimum counts needed to produce rates. The total number of deaths in each five-year interval was divided by the person-years at risk. Mortality rates were age-standardized to the estimated 2001 population age structure of Inuit Nunangat. The Spiegelman method[14] was used to calculate 95% confidence intervals. Rates were also calculated for each of the four regions of Inuit Nunangat. Rate ratios were calculated in order to compare Inuit Nunangat with the rest of Canada.

Results

Overall mortality rates

In 2004-2008, the ASMR at ages 1 to 19 in Inuit Nunangat was 188.0 deaths per 100,000 person-years at risk; this compared with 35.3 deaths per 100,000 in the rest of Canada (Table 2). For both populations, these ASMRs marked a decline from 1994-1998, when the rates had been 210.1 deaths per 100,000 person-years at risk in Inuit Nunangat, and 44.7 in the rest of Canada. The simultaneous decreases in ASMRs meant that the rate ratio comparing children and teenagers in Inuit Nunangat with the rest of Canada did not change significantly over the two periods.

The high overall ASMRs for Inuit Nunangat prevailed across subregions. For instance, in 2004-2008, rates were 152.5 deaths per 100,000 person-years at risk in Nunavut, 307.8 in Nunavik, and 269.1 in Nunatsiavut. Because of small numbers, rates for the Inuvialuit Region were not calculated.

Table 2
Age-standardized mortality rates (ASMR) per 100,000 person-years at risk, by sex, population aged 1 to 19, Canada,† Inuit Nunangat, and Inuit subregions 1994 to 1998 and 2004 to 2008

	Canada			Inuit Nunangat			Nunavut			Nunavik			Nunatsiavut		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
Sex/Years	ASMR	from	to	ASMR	from	to	ASMR	from	to	ASMR	from	to	ASMR	from	to
Both sexes															
1994 to 1998	44.7	44.0	45.4	210.1	182.6	241.7	211.2	176.3	252.9	262.4	200.1	344.1	248.7	147.2	420.1
2004 to 2008	35.3	34.7	35.9	188.0	163.9	215.7	152.5	125.3	185.6	307.8	245.3	386.3	269.1	177.9	407.0
Males															
1994 to 1998	53.2	52.2	54.2	258.2	215.9	308.8	233.7	183.4	297.7	377.1	274.0	519.1	324.0	168.5	623.0
2004 to 2008	41.7	40.7	42.6	244.5	206.6	289.5	210.4	166.7	265.7	366.9	274.6	490.3	348.8	209.0	582.1
Females															
1994 to 1998	35.7	34.9	36.6	161.2	128.6	202.0	188.2	143.7	246.6	146.4	87.8	244.0	173.9	72.3	418.8
2004 to 2008	28.6	27.8	29.4	129.5	102.2	164.2	91.8	63.7	132.3	247.1	171.5	356.1	187.2	92.1	380.5

† excludes residents of Inuit Nunangat
Note: Because of small numbers, rates were not calculated for the Inuvialuit Settlement Region.
Source: Custom population estimates, Demography Division; Vital Statistics Database.

Cause of death

Communicable diseases

Communicable diseases are conditions such as tuberculosis and respiratory infections. In 2004-2008, the ASMR due to communicable diseases for 1- to 19-year-olds was 35.6 deaths per 100,000 person-years at risk in Inuit Nunangat, compared with 9.9 elsewhere in Canada (Table 3). The rate ratio was almost unchanged since 1994-1998, remaining around 3.6 (Table 4).

Non-communicable diseases

Non-communicable diseases are conditions such as cancer, congenital anomalies and neurologic diseases. In 2004-2008, the ASMR for deaths due to non-communicable diseases among children and teenagers was 22.4 deaths per 100,000 person-years at risk in Inuit Nunangat and 12.0 elsewhere in Canada. Since 1994-1998, the ASMRs for non-communicable diseases had fallen in both Inuit Nunangat and the rest of Canada, so the rate ratio was relatively constant over the period at about 2.0.

Injuries

Injuries were the largest contributor to mortality of children and teenagers, accounting for a much larger share of deaths in Inuit Nunangat than in the rest of Canada: 64% versus 36% in 2004-2008 (data not shown). The ASMR for all injuries combined was 115.3 deaths per 100,000 person-years at risk in Inuit Nunangat, compared with 10.9 elsewhere in Canada.

Deaths due to *unintentional* injuries are those in which there was no intent to harm (for example, accidental motor vehicle collisions, unintentional drownings). Deaths due to *intentional* injuries refer to suicide (self-inflicted) and homicide.

In 2004-2008, in Inuit Nunangat, the ASMR per 100,000 person-years at risk was 40.4 deaths for *unintentional* injuries and 74.9 deaths for *intentional* injuries. Rates were much lower elsewhere in Canada, and the rate was higher for *unintentional* (7.8) than for *intentional* injuries (3.1). Since 1994-1998, the rate ratios had not changed significantly.

For children and teenagers in both Inuit Nunangat and the rest of Canada, the majority of deaths due to *intentional* injuries were self-inflicted, that is, suicides; ASMRs for homicide could not be reported because of small numbers. Suicides accounted for a much larger share of all deaths of young people in Inuit Nunagat than elsewhere in Canada: 40% versus 8%.[15-18]

The suicide rate of girls and young women in Inuit Nunangat was approximately 40 deaths per 100,000 person-years at risk from 1994-1998 to 2004-2008, compared with around 2 deaths per 100,000 person-years at risk in the rest of Canada. The rate ratios show suicide rates for girls and young women in Inuit Nunangat to be more than 20 times those in the rest of Canada.

Among boys and young men in Inuit Nunangat, the suicide rate was 77.2 deaths per 100,000 person-years at risk in 1994-1998 and 101.6 in 2004-2008, rates that were not statistically different. By contrast, the suicide rate among boys and young men in the rest of Canada fell significantly from 6.1 to 4.2 deaths per 100,000 person-years at risk. As a result, the suicide rate ratio rose from 15 to 35.

From 1994-1998 to 2004-2008, the percentage of suicides due to hanging/suffocation rose among children and teenagers in Inuit Nunangat (from 70% to 85%) and also in the rest of Canada (from 55% to 72%). Rate ratios for suicides from hanging/suffocation were 38 times higher in Inuit Nunangat than elsewhere in Canada, and those for suicides due to firearms, 51 times higher.

Discussion

Mortality rates among 1- to 19-year-olds in Inuit Nunangat declined since 1994-1998, but so have rates in the rest

Table 3
Age-standardized mortality rates (ASMR) per 100,000 person-years at risk, by sex and cause of death, population aged 1 to 19, Canada† and Inuit Nunangat, 1994 to 1998 and 2004 to 2008

	1994 to 1998						2004 to 2008					
	Canada			Inuit Nunangat			Canada			Inuit Nunangat		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
Sex/Cause of death	ASMR	from	to	ASMR	from	to	ASMR	from	to	ASMR	from	to
Both sexes - All causes	**44.7**	**44.0**	**45.4**	**210.1**	**182.6**	**241.7**	**35.3**	**34.7**	**35.9**	**188.0**	**163.9**	**215.7**
Group I: Communicable diseases	9.4	9.1	9.7	34.3	24.5	48.0	9.9	9.6	10.3	35.6	25.6	49.3
Infectious and parasitic	1.0	0.9	1.1	5.2	2.1	12.4	0.8	0.7	0.9	9.1	4.8	17.6
Group II: Non-communicable diseases	15.7	15.3	16.1	36.3	26.0	50.6	12.0	11.7	12.4	22.4	14.8	33.7
Congenital anomalies	6.9	6.6	7.2	16.4	10.0	26.9	4.7	4.5	5.0	11.5	6.5	20.2
Group III: Injuries	15.5	15.1	15.9	109.6	89.9	133.7	10.9	10.6	11.2	115.3	97.1	136.9
Unintentional	11.2	10.9	11.6	46.8	34.7	63.2	7.8	7.5	8.0	40.4	30.0	54.4
Road traffic	6.6	6.3	6.8	9.6	5.0	18.5	4.3	4.1	4.5	7.7	3.8	15.5
Drownings	1.0	0.9	1.1	X	...	...	0.7	0.6	0.8	7.4	3.7	14.8
Intentional	4.2	4.0	4.4	62.8	48.2	81.8	3.1	3.0	3.3	74.9	60.7	92.5
Self-inflicted	3.3	3.1	3.5	58.5	44.5	77.0	2.2	2.1	2.3	72.1	58.2	89.3
Firearm	0.8	0.7	0.9	16.1	9.5	27.1	0.2	0.1	0.2	9.5	5.2	17.1
Hanging/Suffocation	1.8	1.7	2.0	41.3	29.8	57.3	1.6	1.5	1.7	60.9	48.2	76.9
Males - All causes	**53.2**	**52.2**	**54.2**	**258.2**	**215.9**	**308.8**	**41.7**	**40.7**	**42.6**	**244.5**	**206.6**	**289.5**
Group I: Communicable diseases	10.4	9.9	10.8	40.1	25.8	62.2	10.9	10.4	11.4	40.8	26.6	62.7
Infectious and parasitic	1.1	0.9	1.2	X	...	...	0.8	0.7	1.0	13.9	6.6	29.2
Group II: Non-communicable diseases	16.9	16.3	17.5	41.3	26.6	64.2	13.2	12.7	13.7	18.8	10.1	35.0
Congenital anomalies	7.5	7.2	7.9	22.7	12.5	41.0	4.9	4.6	5.2	12.8	6.1	27.0
Group III: Injuries	20.9	20.3	21.5	147.2	115.6	187.4	14.5	14.0	15.0	163.5	133.5	200.3
Unintentional	14.8	14.3	15.3	68.1	47.9	97.0	10.3	9.9	10.7	58.2	41.1	82.4
Road traffic	8.3	7.9	8.7	16.8	8.4	33.7	5.5	5.2	5.8	11.6	5.2	25.8
Drownings	1.5	1.3	1.7	X	...	...	1.1	1.0	1.3	12.8	6.1	27.0
Intentional	6.1	5.8	6.5	79.1	56.8	110.2	4.2	4.0	4.5	105.3	82.0	135.1
Self-inflicted	5.0	4.7	5.3	77.2	55.2	108.0	2.9	2.7	3.1	101.6	78.9	131.0
Firearm	1.5	1.3	1.6	22.7	12.2	42.1	0.4	0.3	0.4	18.7	10.3	33.8
Hanging/Suffocation	2.6	2.4	2.9	54.5	36.5	81.4	2.0	1.8	2.2	81.3	61.2	108.0
Females - All causes	**35.7**	**34.9**	**36.6**	**161.2**	**128.6**	**202.0**	**28.6**	**27.8**	**29.4**	**129.5**	**102.2**	**164.2**
Group I: Communicable diseases	8.3	7.9	8.8	28.4	16.8	48.1	8.8	8.4	9.3	30.1	18.1	50.0
Infectious and parasitic	0.9	0.8	1.1	X	...	...	0.7	0.6	0.9	X	...	...
Group II: Non-communicable diseases	14.3	13.8	14.9	31.2	18.8	51.9	10.9	10.4	11.4	26.1	15.1	44.9
Congenital anomalies	6.2	5.8	6.6	10.2	4.2	24.5	4.5	4.2	4.9	10.1	4.2	24.3
Group III: Injuries	9.8	9.3	10.2	71.5	50.5	101.1	7.1	6.7	7.4	65.6	47.5	90.6
Unintentional	7.5	7.2	7.9	25.3	14.4	44.7	5.1	4.8	5.4	22.0	12.5	38.8
Road traffic	4.7	4.5	5.1	X	...	...	3.1	2.9	3.3	X	...	...
Drownings	0.5	0.4	0.7	X	...	...	0.3	0.2	0.4	X	...	...
Intentional	2.2	2.0	2.4	46.1	29.7	71.5	2.0	1.8	2.2	43.6	29.4	64.5
Self-inflicted	1.5	1.3	1.6	39.5	24.5	63.5	1.5	1.3	1.6	41.6	27.9	62.1
Firearm	0.1	0.1	0.2	X	...	...	X	...	...	X	...	...
Hanging/Suffocation	1.0	0.9	1.1	27.9	15.8	49.1	1.2	1.1	1.3	39.9	26.5	60.1

† excludes residents of Inuit Nunangat
... not applicable
X suppressed to meet confidentiality requirements of the Statistics Act
Source: Custom population estimates, Demography Division; Vital Statistics Database.

of Canada. Consequently, the rate ratio remained approximately five times higher throughout the decade.

The greatest disparity was for injuries, with rate ratios in 2004-2008 about 10 times higher among children and teenagers in Inuit Nunangat than in the rest of Canada.

In 2004-2008, children and teenagers in Inuit Nunangat were more than 30 times as likely to die from suicide as were those in the rest of Canada. Similarly high suicide rates have been reported for the total population in Inuit regions.[19,20] Half of all deaths of young people in Inuit Nunangat were suicides, compared with approximately 10% in the rest of Canada.

While rate ratios were highest for injuries, disparities also emerged in

Table 4
Rate ratios for age-standardized mortality rates, by sex and cause of death, population aged 1 to 19, Inuit Nunangat compared with Canada,† 1994 to 1998 and 2004 to 2008

	1994 to 1998			2004 to 2008		
		95% confidence interval			95% confidence interval	
Sex/Cause of death	Rate ratio	from	to	Rate ratio	from	to
Both sexes - All causes	**4.7**	**4.1**	**5.4**	**5.3**	**4.6**	**6.1**
Group I: Communicable diseases	3.7	2.6	5.1	3.6	2.6	5.0
Infectious and parasitic	5.2	2.1	12.5	11.7	6.0	22.8
Group II: Non-communicable diseases	2.3	1.7	3.2	1.9	1.2	2.8
Congenital anomalies	2.4	1.5	3.9	2.4	1.4	4.3
Group III: Injuries	7.1	5.8	8.7	10.6	8.9	12.6
Unintentional	4.2	3.1	5.6	5.2	3.9	7.0
Road traffic	1.5	0.8	2.8	1.8	0.9	3.6
Drownings	X	...	...	10.1	5.0	20.5
Intentional	14.9	11.4	19.4	24.1	19.4	29.9
Self-inflicted	17.8	13.5	23.6	32.8	26.2	40.9
Firearm	19.6	11.5	33.4	51.3	27.4	96.1
Hanging/Suffocation	22.5	16.1	31.5	38.0	29.8	48.5
Males - All causes	**4.9**	**4.1**	**5.8**	**5.9**	**5.0**	**7.0**
Group I: Communicable diseases	3.9	2.5	6.0	3.7	2.4	5.7
Infectious and parasitic	X	...	...	16.9	7.9	36.0
Group II: Non-communicable diseases	2.4	1.6	3.8	1.4	0.8	2.7
Congenital anomalies	3.0	1.7	5.5	2.6	1.2	5.5
Group III: Injuries	7.0	5.5	9.0	11.3	9.2	13.8
Unintentional	4.6	3.2	6.6	5.6	4.0	8.0
Road traffic	2.0	1.0	4.1	2.1	0.9	4.7
Drownings	X	...	...	11.5	5.4	24.4
Intentional	12.9	9.2	18.1	25.0	19.3	32.4
Self-inflicted	15.4	10.9	21.7	35.0	26.9	45.6
Firearm	15.5	8.3	29.2	52.4	28.0	98.2
Hanging/Suffocation	20.6	13.7	31.1	40.9	30.4	55.0
Females - All causes	**4.5**	**3.6**	**5.7**	**4.5**	**3.6**	**5.7**
Group I: Communicable diseases	3.4	2.0	5.8	3.4	2.0	5.7
Infectious and parasitic	X	...	...	X	...	...
Group II: Non-communicable diseases	2.2	1.3	3.6	2.4	1.4	4.1
Congenital anomalies	1.6	0.7	4.0	2.2	0.9	5.4
Group III: Injuries	7.3	5.2	10.4	9.3	6.7	12.9
Unintentional	3.4	1.9	6.0	4.3	2.4	7.6
Road traffic	X	...	...	X	...	...
Drownings	X	...	...	X	...	...
Intentional	20.8	13.3	32.5	22.2	14.8	33.3
Self-inflicted	27.2	16.7	44.3	28.4	18.8	43.1
Firearm	...	...	...	...	...	...
Hanging/Suffocation	28.3	15.8	50.7	33.4	21.8	51.2

† excludes residents of Inuit Nunangat
... not applicable
X suppressed to meet confidentiality requirements of Statistics Act
Source: Custom population estimates, Demography Division; Vital Statistics Database.

mortality rates due to communicable diseases. In 2004-2008, children and teenagers in Inuit Nunangat were 3.6 times more likely to die from communicable diseases than were those elsewhere in Canada consistent with other evidence.[21] As well, throughout the decade, children and teenagers in Inuit Nunangat were approximately twice as likely to die due to non-communicable diseases, compared with those in the rest of Canada.

Overall, whether they lived in Inuit Nunangat or in the rest of Canada, girls and young women had lower ASMRs than did boys and young men.

What is already known on this subject?

- Life expectancy at birth for residents of Inuit Nunangat is 6 to 11 years less than that of people in the rest of Canada.
- In 2006, the overall mortality rate of residents of Inuit Nunangat was double that of Canada as a whole.

What does this study add?

- This study provides mortality rates by detailed cause of death for children and teenagers aged 1 to 19 living in Inuit Nunangat, compared with those living elsewhere in Canada for two five-year periods: 1996 (1994-1998) and 2006 (2004-2008).
- Age-standardized mortality rates were higher for children and teenagers in Inuit Nunangat compared with the rest of Canada in both 1994-1998 and 2004-2008.
- Injuries accounted for the largest component of mortality among children and teenagers in Inuit Nunangat.
- In 2004-2008, age-standardized suicide rates were up to 30 times higher among children and teenagers in Inuit Nunangat than in the rest of Canada.

Limitations

While the use of national death records to calculate mortality rates for Inuit Nunangat is a strength of this study, this data source has inherent limitations. Because Vital Statistics data do not contain Inuit identifiers, this analysis used a geographic approach to produce mortality rates for Inuit regions rather than for the Inuit population per se. Thus, the rates presented here are not representative of all Inuit in Canada.

As well, the Vital Statistics data record only the primary cause of death, although it is possible that some deaths had multiple underlying causes.

The mortality rates for youth living in Inuit Nunangat are based on small populations and very small numbers of deaths. Confidence intervals are wide and frequently overlap. As a result, what may seem to be substantial differences can be based on few events, and apparently large changes are not significant. In fact, low numbers prevented separate calculations of ASMRs by cause of death for the four Inuit Nunangat land claims regions, and the number of deaths in the Inuvialuit Settlement Region was so low that separate ASMRs could not be calculated.

Conclusion

The findings show higher mortality rates for children and teenagers in Inuit Nunangat, compared with the rest of Canada. The overall mortality rate in 2004-2008 was about five times higher, a disparity that has persisted since the mid-1990s. Self-inflicted injuries are the largest contributor to mortality among young people living in Inuit Nunangat. ■

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Cause-specific mortality by education in Canada: A 16-year follow-up study

by Michael Tjepkema, Russell Wilkins and Andrea Long

Abstract

Background
People with lower levels of education tend to have higher rates of disease and death, compared with people who have higher levels of education. However, because death registrations in Canada do not contain information on the education of the deceased, unlinked vital statistics cannot be used to examine mortality differentials by education.

Methods
This study examines cause-specific mortality rates by education in a broadly representative sample of Canadians aged 25 or older. The data are from the 1991 to 2006 Canadian census mortality follow-up study, which included about 2.7 million people and 426,979 deaths. Age-standardized mortality rates (ASMRs) were calculated by education for different causes of death. Rate ratios, rate differences and excess mortality were also calculated.

Results
All-cause ASMRs were highest among people with less than secondary graduation and lowest for university degree-holders. If all cohort members had the mortality rates of those with a university degree, the overall ASMRs would have been 27% lower for men and 22% lower for women. The causes contributing most to that "excess" mortality were ischemic heart disease, lung cancer, chronic obstructive pulmonary disease, stroke, diabetes, injuries (men), and respiratory infections (women). Causes associated with smoking and alcohol abuse had the steepest gradients.

Interpretation
A mortality gradient by education was evident for many causes of death.

Keywords
Age-standardized mortality rates, rate differences, rate ratios, socio-economic inequalities

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The social, economic and environmental conditions that people experience throughout their lives are the most important influences on their health.[1] Known as the *social determinants of health*, these factors include income, occupation, living conditions, and importantly, education.

The level of education that a person achieves is influenced by circumstances that include family income during childhood and intergenerational effects such as the mother's education.[1,2-5] Differences in educational attainment may be associated with different health trajectories. People with lower levels of education tend to have high rates of disease and mortality, compared with those with higher levels of attainment.[6]

Education can affect health through multiple pathways.[6,7] Educational attainment may be an indicator of intra- and inter-personal skills that are needed to produce and maintain good health.[8,9] Health literacy—the ability to access and use health information to make decisions that contribute to the maintenance of basic health—is considered a critical link between education and health outcomes.[10] People with higher levels of education may be more receptive to prevention messages and better able to change their behaviours and to use the health care system effectively.[11] For instance, people with higher levels of education may be less likely to engage in health risk behaviours, such as smoking.[12] Education is also closely connected with other social determinants of health. Higher attainment can increase opportunities for employment and income security,[1] and research consistently documents better health in higher-income groups.[13-15]

The association between education and mortality is well established in western and eastern European countries.[16,17] In Canada, however, death registrations do not contain information about the education of the deceased. As a result, unlinked vital statistics cannot be used to examine differences in mortality by level of education. To overcome this obstacle, several smaller-scale record linkage-based mortality follow-up studies have been conducted.[18-23] These studies demonstrated socio-economic differentials in mortality in Canada, but their applicability may be limited by the scope of the universe covered (geographically, or by age, sex and/or occupation), small sample size, lack of information about causes of death, or a combination of factors.

Recently, a broadly representative sample of Canadian adults aged 25 or older was linked to almost 16 years of mortality data.[24-26] This cohort has been used to examine gradients in all-cause mortality (and life expectancy) by various socio-economic indicators. All-cause mortality rates were shown to be lower in each successively higher category of socio-economic status, whether defined by income, education or occupation. But the cohort has not been used to assess educational gradients in cause-specific death rates. The objective of this study, therefore, is to examine cause-specific mortality rates by level of education to determine if the association between education and mortality differs by cause of death.

Table 1
Educational attainment, by sex and age group, non-institutional cohort members aged 25 or older, Canada, 1991 (baseline)

Sex and age group	Total number	Less than secondary graduation	Secondary graduation	Post-secondary diploma	University degree
			%		
Men					
25 or older	1,358,200	35.0	37.6	12.4	15.1
25 to 44	725,500	24.1	42.7	15.7	17.5
45 to 64	433,400	41.4	34.6	9.9	14.0
65 to 74	135,700	58.0	26.9	6.2	8.9
75 or older	63,600	65.3	22.3	4.9	7.5
Women					
25 or older	1,376,600	34.8	35.2	18.4	11.7
25 to 44	765,100	23.0	40.2	21.5	15.3
45 to 64	388,300	42.7	31.5	16.9	8.9
65 to 74	136,300	59.3	25.9	10.5	4.3
75 or older	86,800	64.2	21.9	10.0	3.9

Source: 1991 to 2006 Canadian census mortality and cancer follow-up study.

Methods

The data are from the 1991-to-2006 Canadian census mortality follow-up study, which tracked mortality in a 15% sample of the adult population.[24-26] Respondents to the 1991 Census were eligible to be included in the study cohort if they were: (1) 25 or older and a usual resident of Canada on the day of the census (June 4, 1991); (2) not a long-term resident of an institution such as a prison, hospital or nursing home; and (3) enumerated using the long-form questionnaire that was administered to one in five private households, and to all residents of non-institutional collective dwellings and Indian reserves. Approximately 3.6 million individuals met these criteria.

The electronic 1991 census database does not contain names, which are needed to determine mortality. To obtain names, census records were first linked to tax-filer data from 1990 and 1991 using probabilistic matching, based on dates of birth and postal codes of the individual and his/her spouse or common-law partner (if any). About three-quarters of those who were in-scope were successfully linked to non-financial tax-filer data. The cohort was then linked to the Canadian Mortality Database (June 4, 1991 to December 31, 2006) using probabilistic methods.[27] Even without a match to a death registration, follow-up status (alive, dead, emigrated, or lost to follow-up) could usually be determined from tax-filer data.[25] Overall, the cohort consisted of 2.7 million people, 16% of whom (426,979) died during the follow-up period (Appendix Table A).

Underlying cause of death was coded according to the World Health Organization's *International Classification of Diseases, Ninth Revision*[28] for deaths that occurred in 1991 through 1999, and according to the *Tenth Revision*[29] for deaths that occurred in 2000 through 2006. Deaths were grouped by Global Burden of Disease categories,[30] and by behavioural health risk factors, namely, smoking-related,[16] alcohol-related,[16] and drug-related[31] diseases. Deaths before age 75 that were potentially amenable to medical intervention, such as those due to cerebrovascular disease, hypertension, breast cancer and pneumonia/influenza,[16,32] were also examined.

Highest level of education at cohort inception (baseline) was grouped into four categories: less than secondary graduation, secondary graduation (or trades certificate), postsecondary certificate or diploma (short of a bachelor's degree), and university degree.

For each cohort member, person-days of follow-up were calculated from the day of the census (June 4, 1991) to the date of death, date of emigration or the last day of the study period (December 31, 2006). Person-days of follow-up were divided by 365.25 to obtain person-years at risk. Age-at-baseline-, sex-, and educational attainment-specific mortality rates by 5-year age groups were used to calculate age-standardized mortality rates (ASMRs), using the cohort population structure (person-years at risk), both sexes together, as the standard population.

Relative inequalities were assessed by rate ratios (RRs) and percent excess mortality. RRs were calculated by dividing the ASMR for those with lower levels of education (less than secondary graduation, secondary graduation, or postsecondary diploma) by the ASMR for those with a university degree. RRs greater than 1.00 indicate an increased mortality risk. Percent excess mortality was calculated by subtracting the ASMR for those with a university degree from the ASMR for the total cohort, then dividing by the total ASMR and multiplying by 100.

Absolute inequalities were assessed by rate differences (RDs) and absolute excess mortality. RDs were calculated

by subtracting the ASMR for those with a university degree from the ASMR of those with lower levels of education (less than secondary graduation, secondary graduation, or postsecondary diploma). RDs greater than zero indicate excess mortality. Absolute excess mortality was calculated by subtracting the ASMR of those with a university degree from the ASMR for the total cohort. The difference represents the number of deaths (per 100,000) that hypothetically could have been avoided if all cohort members had experienced the mortality rate of those with a university degree.

Based on previously described methods,[33] 95% confidence intervals for ASMRs, RRs and RDs were calculated.

Results

The percentages of male and female cohort members, respectively, at each level of education were 35% and 35% for less than secondary graduation, 38% and 35% for secondary graduation, 12% and 18% for postsecondary diploma, and 15% and 12% for university degree (Table 1). Younger cohort members tended to have higher levels of education than did older members.

The ASMR for all causes of death showed a clear stair-stepped gradient by level of education, with higher mortality rates for those with lower levels of education. Compared with people who had a university degree, the rate ratio (RR) for those with less than secondary graduation was 1.55 for men and 1.44 for women (Tables 2 and 3).

Table 2
Age-standardized mortality rates per 100,000 person-years at risk for selected causes of death, by educational attainment, male cohort members aged 25 or older at baseline, Canada 1991 to 2006

Cause of death	Total	University degree	Post-secondary diploma	Secondary graduation	Less than secondary graduation	RR	RD	Excess	% excess
All causes	**1,372.8**	**1,008.9**	**1,145.7**	**1,315.2**	**1,561.9**	**1.55***	**553.0***	**363.9**	**26.5**
Communicable diseases	57.1	50.9	49.7	53.0	62.1	1.22*	11.1*	6.2	10.8
HIV/AIDS	5.8	7.4	6.7	5.6	4.7	0.63*	-2.7*	-1.5	-26.5
Respiratory infections	36.4	31.5	30.6	33.9	39.9	1.27*	8.4*	4.9	13.5
Non-communicable diseases	1,188.4	863.8	993.7	1,139.2	1,342.8	1.55*	479.0*	324.6	27.3
Malignant neoplasms	416.5	296.3	353.9	408.3	467.3	1.58*	171.0*	120.2	28.9
Stomach cancer	15.5	9.5	12.4	14.0	18.5	1.94*	9.0*	6.0	38.6
Colon and rectal cancers	44.0	34.3	40.7	43.0	48.0	1.40*	13.7*	9.7	22.0
Liver cancer	9.0	6.6	8.5	8.8	10.0	1.52*	3.4*	2.4	26.9
Pancreatic cancer	19.9	18.6	18.7	20.0	20.9	1.12	2.3	1.3	6.6
Trachea, bronchus, and lung cancers	124.1	55.3	84.3	115.5	154.7	2.80*	99.3*	68.7	55.4
Prostate cancer	51.7	46.2	50.9	51.3	53.0	1.15*	6.9*	5.5	10.6
Diabetes mellitus	38.3	25.0	30.5	34.9	45.6	1.83*	20.6*	13.3	34.7
Neuropsychiatric conditions	65.7	65.4	64.0	63.2	70.4	1.08*	5.0	0.3	0.4
Alcohol use disorders	5.0	2.5	3.4	4.4	7.0	2.82*	4.5*	2.6	50.9
Alzheimer's disease and other dementias	32.9	34.6	32.9	32.5	33.0	0.96	-1.5	-1.7	-5.1
Cardiovascular diseases	483.4	360.3	408.1	459.6	544.3	1.51*	184.0*	123.1	25.5
Ischemic heart disease	293.3	209.5	246.7	279.8	333.5	1.59*	124.0*	83.8	28.6
Cerebrovascular disease	79.3	67.8	65.8	74.6	87.3	1.29*	19.5*	11.5	14.5
Respiratory diseases	86.0	47.2	59.9	76.7	102.5	2.17*	55.3*	38.8	45.1
Chronic obstructive pulmonary disease	65.4	31.1	40.5	56.0	80.3	2.58*	49.2*	34.4	52.5
Digestive diseases	46.5	29.6	34.0	45.5	55.1	1.86*	25.5*	16.9	36.4
Cirrhosis of the liver	15.1	7.7	10.3	15.3	18.8	2.44*	11.1*	7.4	48.9
Injuries	70.2	47.0	54.2	69.3	91.3	1.94*	44.4*	23.2	33.1
Unintentional injuries	45.7	32.1	37.0	45.3	58.2	1.81*	26.1*	13.6	29.8
Road traffic accidents	7.9	5.1	6.4	7.8	10.1	1.98*	5.0*	2.8	35.3
Intentional injuries	24.4	14.8	17.2	24.0	33.1	2.23*	18.3*	9.6	39.2
Suicide	22.7	13.9	16.2	22.6	30.2	2.17*	16.3*	8.8	38.7
Smoking-related diseases	216.2	102.6	143.9	198.3	266.1	2.59*	163.5*	113.5	52.5
Alcohol-related diseases	15.8	7.4	9.6	15.1	21.6	2.90*	14.1*	8.4	53.0
Drug-related diseases	5.4	3.4	3.4	5.5	7.7	2.25*	4.3*	2.0	36.7
Amenable to medical intervention (younger than 75)	141.8	121.8	128.5	138.8	152.4	1.25*	30.6*	20.0	14.1

* significantly different from rate for university degree ($p < 0.05$)
RR = rate ratio (less than secondary graduation / university degree)
RD = rate difference (less than secondary graduation - university degree)
Excess = (total - university degree)
% excess = [100 * (total - university degree)/total]
Note: Reference population (person-years at risk) for age-standardization was taken from internal cohort age distribution (5-year age groups).
Source: 1991 to 2006 Canadian census mortality and cancer follow-up study.

Table 3
Age-standardized mortality rates per 100,000 person-years at risk for selected causes of death, by educational attainment, female cohort members aged 25 or older at baseline, Canada 1991 to 2006

Cause of death	Total	University degree	Post-secondary diploma	Secondary graduation	Less than secondary graduation	RR	RD	Excess	% excess
All causes	**869.4**	**677.7**	**736.6**	**820.9**	**977.7**	**1.44***	**300.0***	**191.7**	**22.0**
Communicable diseases	34.2	27.2	29.0	31.7	39.0	1.43*	11.8*	7.0	20.4
HIV/AIDS	0.5	0.3	0.2	0.5	0.9	3.21*	0.6*	0.2	40.9
Respiratory infections	21.8	17.1	19.1	20.7	23.9	1.40*	6.9*	4.7	21.7
Non-communicable diseases	748.0	581.2	639.4	710.1	835.0	1.44*	253.8*	166.8	22.3
Malignant neoplasms	273.3	231.1	250.1	272.6	294.8	1.28*	63.7*	42.2	15.5
Stomach cancer	6.8	4.8	5.5	6.1	8.0	1.64*	3.1*	2.0	29.4
Colon and rectal cancers	28.0	23.8	26.7	27.9	29.8	1.25*	5.9*	4.2	14.8
Liver cancer	4.3	3.2	4.0	3.8	4.9	1.57*	1.8	1.1	26.1
Pancreatic cancer	14.9	11.0	13.4	15.6	15.5	1.41*	4.5*	3.9	26.2
Trachea, bronchus, and lung cancers	61.7	29.2	45.1	59.3	77.0	2.64*	47.8*	32.4	52.6
Female breast cancer	49.2	57.2	51.1	51.8	46.0	0.80*	-11.2*	-8.1	-16.4
Cervix uteri cancer	3.8	2.3	2.8	3.3	5.3	2.36*	3.1*	1.5	40.5
Ovarian cancer	14.5	15.3	14.9	14.7	14.1	0.92	-1.2	-0.8	-5.9
Diabetes mellitus	24.3	11.6	14.3	18.4	32.1	2.78*	20.5*	12.8	52.5
Neuropsychiatric conditions	55.9	57.3	53.0	55.2	58.5	1.02	1.2	-1.3	-2.4
Alcohol use disorders	1.5	0.8	0.9	1.2	2.3	2.77*	1.5	0.6	43.2
Alzheimer's disease and other dementias	36.7	36.3	35.5	36.5	37.1	1.02	0.8	0.3	0.9
Cardiovascular diseases	280.4	204.3	231.3	258.5	315.6	1.54*	111.3*	76.0	27.1
Ischemic heart disease	142.0	97.1	111.6	129.0	162.5	1.67*	65.4*	44.8	31.6
Cerebrovascular disease	64.0	52.9	57.0	61.6	69.1	1.31*	16.2*	11.1	17.4
Respiratory diseases	42.5	23.6	32.4	37.4	51.2	2.17*	27.6*	18.9	44.4
Chronic obstructive pulmonary disease	30.1	14.2	21.8	25.9	36.7	2.59*	22.5*	15.9	52.9
Digestive diseases	32.3	22.4	24.2	31.4	38.0	1.69*	15.6*	9.9	30.6
Cirrhosis of the liver	7.1	3.8	4.5	6.7	9.6	2.55*	5.9*	3.3	46.8
Injuries	31.2	29.4	30.3	30.2	36.2	1.23*	6.8*	1.9	6.0
Unintentional injuries	24.4	24.0	23.9	23.2	27.9	1.16*	3.9	0.4	1.5
Road traffic accidents	3.5	3.6	3.7	3.2	4.3	1.18	0.6	-0.1	-3.1
Intentional injuries	6.9	5.4	6.4	7.0	8.3	1.55*	3.0*	1.5	21.9
Suicide	6.0	4.5	6.0	6.0	7.1	1.58*	2.6*	1.5	25.6
Smoking-related diseases	100.8	49.7	74.0	94.3	124.2	2.50*	74.5*	51.1	50.7
Alcohol-related diseases	5.7	2.9	3.7	5.6	8.0	2.75*	5.1*	2.8	49.1
Drug-related diseases	4.5	2.6	3.6	4.3	6.9	2.68*	4.3*	1.9	43.0
Amenable to medical intervention (younger than 75)	148.4	133.7	138.5	147.4	156.5	1.17*	22.8*	14.8	9.9

* significantly different from rate for university degree ($p < 0.05$)
RR = rate ratio (less than secondary graduation / university degree)
RD = rate difference (less than secondary graduation - university degree)
Excess = (total - university degree)
% excess = [100 * (total - university degree)/total]
Note: Reference population (person-years at risk) for age-standardization was taken from internal cohort age distribution (5-year age groups).
Source: 1991 to 2006 Canadian census mortality and cancer follow-up study.

The mortality gradient by education differed by cause of death. For men, RRs comparing those with less than secondary graduation to those with a university degree were particularly high for deaths due to trachea, bronchus and lung cancers (RR=2.80), chronic obstructive pulmonary disease (RR=2.58), and cirrhosis of the liver (RR=2.44) (Table 2). By contrast, the gradient was reversed for deaths due to HIV/AIDS (RR=0.63), and not statistically different for pancreatic cancer (RR=1.12) and dementia (RR=0.96).

For women, the RRs comparing those with less than secondary graduation to university degree-holders were notably high for deaths due to trachea, bronchus and lung cancers (RR=2.64), alcohol use disorders (RR=2.77), chronic obstructive pulmonary disease (RR=2.59), and cirrhosis of the liver (RR=2.55) (Table 3). On the other hand, the gradient was reversed for female breast cancer (RR=0.80), and not statistically different for ovarian cancer (RR=0.92), dementia (RR=1.02), and road traffic accidents (RR=1.18).

The education-related percentage "excess" (last column in Tables 2 and 3) shows that if every cohort member had experienced the age-specific mortality rates of those with a university degree, the all-cause ASMR would have been 27% lower for men and 22% lower for women, representing 364 and 192

Table 4
Age-standardized mortality rates per 100,000 person-years at risk for selected causes of death, by educational attainment, age group and sex, cohort members aged 25 or older at baseline, Canada 1991 to 2006

Sex, age group at baseline and cause of death	Total	University degree	Post-secondary diploma	Secondary graduation	Less than secondary graduation	RR	RD	Excess	% excess
Men									
25 to 44									
All causes	211.5	117.6	159.4	216.6	305.6	2.60*	188.0*	93.9	44.4
Unintentional injuries	27.7	11.0	18.6	28.5	44.1	4.01*	33.1*	16.7	60.3
Ischemic heart disease	30.6	14.4	22.7	30.7	47.8	3.31*	33.3*	16.2	52.9
Suicide	23.8	12.5	17.7	25.2	33.2	2.66*	20.7*	11.3	47.5
Trachea, bronchus, and lung cancers	13.1	4.9	8.8	14.5	19.9	4.07*	15.0*	8.2	62.7
45 to 64									
All causes	1,319.3	807.4	1,048.6	1,251.4	1,583.6	1.96*	776.2*	512.0	38.8
Ischemic heart disease	274.6	159.6	224.9	261.8	330.9	2.07*	171.4*	115.1	41.9
Trachea, bronchus, and lung cancers	181.7	72.2	121.6	165.8	239.4	3.32*	167.2*	109.5	60.3
Chronic obstructive pulmonary disease	42.4	12.4	22.1	34.5	59.5	4.79*	47.1*	30.0	70.7
Cerebrovascular disease	51.6	31.5	35.9	48.3	62.8	2.00*	31.3*	20.1	39.0
65 to 74									
All causes	5,304.4	3,923.5	4,320.0	5,058.1	5,775.8	1.47*	1,852.3*	1,380.8	26.0
Ischemic heart disease	1,180.8	818.3	986.6	1,124.4	1,292.8	1.58*	474.6*	362.5	30.7
Trachea, bronchus, and lung cancers	499.5	225.3	327.4	464.1	584.1	2.59*	358.8*	274.2	54.9
Chronic obstructive pulmonary disease	318.9	137.1	166.3	267.9	392.0	2.86*	254.9*	181.8	57.0
Cerebrovascular disease	333.1	266.4	266.1	308.2	364.8	1.37*	98.4*	66.7	20.0
75 or older									
All causes	9,517.4	8,201.0	8,417.8	9,078.8	9,988.4	1.22*	1,787.4*	1,316.4	13.8
Ischemic heart disease	2,187.4	1,844.3	1,896.9	2,083.8	2,304.1	1.25*	459.9*	343.1	15.7
Trachea, bronchus, and lung cancers	568.4	294.6	428.1	516.9	643.7	2.18*	349.1*	273.8	48.2
Chronic obstructive pulmonary disease	594.4	332.8	402.9	523.2	678.8	2.04*	346.0*	261.6	44.0
Diabetes mellitus	247.3	207.9	195.4	227.1	265.2	1.28*	57.3*	39.4	15.9
Women									
25 to 44									
All causes	134.5	87.2	109.6	131.5	193.1	2.22*	105.9*	47.4	35.2
Trachea, bronchus, and lung cancers	13.9	5.2	9.9	14.2	22.6	4.38*	17.4*	8.8	63.0
Ischemic heart disease	6.6	2.5	4.7	6.3	11.5	4.61*	9.0*	4.2	62.6
Unintentional injuries	9.0	5.6	7.9	8.1	14.2	2.52*	8.6*	3.4	37.7
Suicide	6.8	4.2	6.5	6.9	8.5	2.04*	4.3*	2.6	38.5
45 to 64									
All causes	780.9	521.5	616.0	717.0	926.2	1.78*	404.7*	259.5	33.2
Trachea, bronchus, and lung cancers	103.4	42.6	71.9	97.3	131.2	3.08*	88.6*	60.8	58.8
Ischemic heart disease	89.9	33.7	56.1	79.1	118.0	3.50*	84.3*	56.2	62.5
Chronic obstructive pulmonary disease	27.8	6.8	17.4	20.0	39.8	5.83*	33.0*	21.0	75.4
Diabetes mellitus	24.0	8.3	12.9	17.5	34.3	4.11*	26.0*	15.6	65.2
65 to 74									
All causes	3,198.6	2,493.2	2,660.5	2,993.8	3,446.1	1.38*	952.9*	705.4	22.1
Ischemic heart disease	571.8	396.0	408.0	505.6	645.5	1.63*	249.4*	175.8	30.7
Trachea, bronchus, and lung cancers	196.6	100.8	155.7	187.3	216.0	2.14*	115.2*	95.8	48.7
Chronic obstructive pulmonary disease	146.7	62.8	99.6	126.9	170.8	2.72*	108.0*	83.9	57.2
Cerebrovascular disease	250.9	188.0	218.8	241.4	266.1	1.42*	78.1*	62.9	25.1
75 or older									
All causes	6,420.2	5,682.1	5,740.0	6,151.6	6,694.0	1.18*	1,011.9*	738.1	11.5
Ischemic heart disease	1,350.0	1,105.5	1,165.4	1,244.3	1,439.5	1.30*	334.0*	244.5	18.1
Chronic obstructive pulmonary disease	228.7	144.6	181.9	219.2	246.6	1.71*	102.0*	84.1	36.8
Diabetes mellitus	171.9	103.2	107.3	131.5	203.2	1.97*	100.0*	68.7	40.0
Trachea, bronchus, and lung cancers	179.3	124.0	144.1	177.2	190.4	1.54*	66.5*	55.3	30.9

* significantly different from rate for university degree ($p < 0.05$)
RR = rate ratio (less than secondary graduation / university degree)
RD = rate difference (less than secondary graduation - university degree)
Excess = (total - university degree)
% excess = [100 * (total - university degree)/total]
Note: Reference population (person-years at risk) for age-standardization was taken from internal cohort age distribution (5-year age groups).
Source: 1991 to 2006 Canadian census mortality and cancer follow-up study.

fewer deaths per 100,000, respectively. ASMRs for trachea, bronchus and lung cancers, diabetes mellitus (women), chronic obstructive pulmonary disease, and alcohol use disorders (men) would each have been at least 50% lower.

The causes of death contributing the most to education-related absolute excess mortality (next-to-last column in Tables 2 and 3) were ischemic heart disease, lung cancer, chronic obstructive pulmonary disease, cerebrovascular disease, diabetes, injuries (men), and respiratory infections (women). Together, these seven causes accounted for about two-thirds of the total education-related excess mortality for men (65%) and women (64%) (percentages not shown).

RRs for smoking-, alcohol- and drug-related disease deaths all exceeded 2.00 (Tables 2 and 3). ASMRs for smoking- and alcohol-related diseases would have been about 50% lower if all cohort members had experienced the age-specific mortality rates of cohort members with a university degree.

For deaths potentially amenable to medical intervention, the gradient in mortality by education was less steep (RR=1.25 for men and 1.17 for women). The percent excess was 14% for men and 10% for women.

The gradient in RRs by education was steepest in the youngest age group (25 to 44 at baseline) and less steep in each successively older age group (Table 4). For men, the RRs were 2.60 at ages 25 to 44 and 1.22 at age 75 or older. For women, the RRs were 2.22 at ages 25 to 44 and 1.18 at age 75 or older. Although RRs across levels of educational attainment were highest in younger age groups, absolute differences were greatest in older age groups (among whom most deaths occur).

The causes of death that contributed the most to excess mortality differed by sex and age group. Among cohort members aged 25 to 44 at baseline, unintentional injuries was the largest contributor to excess mortality for men, and cancer of the trachea, bronchus and lung was the largest contributor for women. For both sexes aged 45 to 74, ischemic heart disease and lung cancer were the two largest contributors to excess mortality. For those aged 75 or older, ischemic heart disease was the largest contributor, followed by chronic obstructive pulmonary disease for women and lung cancer for men.

Discussion

This analysis shows important differences in cause-specific mortality rates by level of education. For most causes of death, the higher the level of educational attainment, the lower the mortality rate, which is broadly consistent with European[11,16] and American[8,9,34] research. Compared with university degree-holders, people with less than secondary graduation had age-standardized mortality rate ratios of 1.55 for men and 1.44 for women. If the entire cohort had experienced the age-specific mortality rates of those with a university degree, the all-cause ASMR would have been 27% lower for men and 22% lower for women. Extrapolated to the total non-institutional adult population, that equates to an estimated 50,000 fewer deaths per year: 33,000 among men and 17,000 among women. A similar reduction in mortality could have been achieved if all ischemic heart disease and cerebrovascular disease deaths had been eliminated.

Among the causes of death that contribute the most to absolute excess mortality, cardiovascular diseases (including ischemic heart disease and cerebrovascular disease) consistently rank as the most costly in terms of health care system use and lost productivity due to morbidity and premature mortality. Respiratory illnesses such as chronic obstructive pulmonary disease are also among the top five with respect to the direct and indirect economic burden of illness.[35,36]

In terms of RRs, causes of death closely associated with health risk behaviours (for instance, smoking and excessive alcohol consumption) tended to have a steeper mortality gradient by education than did causes not as strongly associated with those behaviours. This is consistent with research indicating that people in lower socio-economic categories are more likely to engage in health risk behaviours.[15,37-39]

The current study revealed greater relative inequalities at younger than at older ages. It has been suggested that a selection effect may be operating at older ages: individuals with lower socio-economic status may die earlier, so that only the healthiest survive into old age, leading to reduced socio-economic inequalities in mortality.[11] It is also possible that the decrease in relative risks

Why is this study important?

- The reduction of socio-economic inequalities in health outcomes is an explicit objective of health policies in Canada.
- Understanding socio-economic inequalities by cause of death may help achieve this objective.

What is already known on this subject?

- All-cause mortality rates are higher for people with relatively low levels of educational attainment.

What does this study add?

- If all cohort members had experienced the age-specific mortality rates of those with a university degree, the age-standardized mortality rate would have been 27% lower for men, and 22% lower for women.
- For both sexes, the causes of death contributing most to that "excess" mortality were ischemic heart disease, lung cancer, chronic obstructive pulmonary disease, stroke, diabetes, injuries (men) and respiratory infections (women).

may be partly explained by attenuation of the association between risk factors and chronic diseases in old age.[40] However, absolute differences in mortality rates were larger in older age groups (65 to 74 and 75 or older) than in younger age groups. Thus, reduction in mortality inequalities at older ages would have the greatest impact on reducing the number of education-related excess deaths.

Strengths and limitations

The large sample on which this study is based is broadly representative of all Canadian adults, and allowed for analysis of mortality differences (in relative and absolute terms) by education within detailed cause of death groupings.

This study was not intended to assess the relative importance of direct and indirect effects of education on mortality: for example, to what extent could educational differences in mortality be explained by associated differences in income?

The data did not include information on risk factors (such as smoking), and thus, might overestimate the effect of education on mortality. Nevertheless, other research concludes that socio-economic differences in various health outcomes (including mortality) largely persist even after controlling for behavioural risk factors.[7,41,42] Further research to determine the degree to which individual behaviours and risk factors explain (or fail to explain) the higher mortality rates experienced by persons of lower socio-economic status in Canada would require long-term mortality follow-up from health surveys that collect data on behavioural risk factors and on indicators of socio-economic status.

This analysis was based on the credentials cohort members had attained by June 4, 1991. Since then, Canadians have become more educated, so the percentage of the population in the lowest attainment levels has declined. This would reduce education-related excess mortality, assuming that the relative risks remained unchanged. However, while this study provides baseline data on the nature and extent of education-related inequalities in mortality, it cannot determine if those inequalities have persisted, increased or decreased over time. Only future linkages of mortality data to more recent censuses (or to the National Household Survey) can provide the data needed to assess such changes.

Conclusion

This study demonstrates important differences in mortality rates by level of education for most causes of death. Causes more closely associated with health risk behaviours tended to have a steeper gradient in mortality by education than did causes not as strongly associated with those behaviours. These results build on previous research by providing evidence by cause-specific groups, and confirm the existence of a consistent gradient in mortality by education across most causes of death. With the extension of the 1991-to-2006 Canadian census mortality follow-up study to include linkage to cancer data, future work could examine the nature and extent of educational inequalities in cancer incidence and survival. ■

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Appendix

Table A
Cohort members aged 25 or older, person-years at risk, and deaths ascertained, by age group and educational attainment at baseline, by sex, Canada, 1991 to 2006

	Men			Women		
Age group and educational attainment	Cohort members	Person-years at risk	Number of deaths	Cohort members	Person-years at risk	Number of deaths
Total 25 or older						
Less than secondary graduation	474,900	6,249,140	138,071	478,500	6,563,790	110,472
Secondary graduation	510,400	7,318,980	69,084	484,000	7,096,100	47,128
Postsecondary diploma	168,300	2,457,660	15,493	253,000	3,734,390	19,960
University degree	204,600	2,942,760	18,339	161,100	2,379,250	8,432
25 to 44						
Less than secondary graduation	175,000	2,616,330	8,066	176,200	2,651,730	5,243
Secondary graduation	309,800	4,649,830	9,981	307,200	4,649,350	6,010
Postsecondary diploma	113,700	1,708,250	2,690	164,600	2,487,060	2,654
University degree	127,000	1,868,330	2,330	117,100	1,749,410	1,516
45 to 64						
Less than secondary graduation	179,600	2,484,030	43,532	165,700	2,402,990	24,071
Secondary graduation	149,900	2,144,350	25,829	122,400	1,810,250	12,369
Postsecondary diploma	43,100	625,240	5,949	65,500	975,020	5,482
University degree	60,800	888,540	6,268	34,700	517,610	2,342
65 to 74						
Less than secondary graduation	78,700	851,130	48,956	80,800	1,015,830	35,470
Secondary graduation	36,500	415,050	20,772	35,300	459,080	13,749
Postsecondary diploma	8,400	99,940	4,213	14,300	189,510	5,051
University degree	12,100	147,970	5,649	5,900	79,360	1,986
75 or older						
Less than secondary graduation	41,500	297,650	37,517	55,700	493,230	45,688
Secondary graduation	14,200	109,760	12,502	19,000	177,410	15,000
Postsecondary diploma	3,100	24,220	2,641	8,700	82,800	6,773
University degree	4,800	37,930	4,092	3,400	32,880	2,588

Note: Cohort member counts rounded to nearest 100; person-years at risk to nearest 10.
Source: 1991 to 2006 Canadian census mortality and cancer follow-up study.

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Informal caregiving for seniors

by Annie Turner and Leanne Findlay

Abstract
Based on data from the 2008/2009 Canadian Community Health Survey–Healthy Aging, this study examines the characteristics of people aged 45 or older who reported caring for a senior. It also describes the nature of the care provided and the positive and negative aspects of caregiving. More than one-third (35%) of Canadians aged 45 or older reported caring for a senior with a short- or long-term health condition or limitation. Compared with non-caregivers, those providing care to a senior were more likely to be women. They tended to be younger and more likely to live in higher-income households and to be postsecondary graduates. More than half the people receiving care were parents or parents-in-law, and they usually did not live with the caregiver. The most common form of care provided was transportation. A third of caregivers had been providing assistance for at least five years. Virtually all (95%) of them reported positive aspects of caregiving, but more than half (56%) experienced challenges and difficulties.

Keywords
Aged, caregiving, elderly, geriatrics, social support

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As Canadians age, informal caregiving becomes increasingly important to the well-being of seniors. According to the 2008/2009 Canadian Community Health Survey (CCHS)–Healthy Aging, an estimated 3.8 million Canadians who were aged 45 or older (35%) were providing informal care to a senior with a short- or long-term health condition. Informal caregivers—family and friends who provide unpaid assistance with tasks such as transportation and personal care—help seniors remain in their homes, thereby reducing demands on the health care system.[1] Moreover, remaining in one's home is usually the preference of seniors themselves.[2,3]

Caring for someone with a health condition or limitation, particularly cognitive impairments such as Alzheimer's disease and dementia, can cause physical and emotional problems and create financial and social burdens for the caregiver.[2,4-7] This may be especially true for caregivers who, themselves, are seniors.[8] On the other hand, providing care can give individuals pleasure and pride, enhance their self-worth, and help them to build relationships with the care recipient.[9]

Based on data from the 2008/2009 CCHS–Healthy Aging, this study compares the characteristics of caregivers with those of their contemporaries who are not caregivers (see *The data*). In addition, the characteristics of the care that caregivers provide are outlined, as are the positive and negative aspects of caregiving.

Caregivers

In 2008/2009, women made up just over half (57%) of people aged 45 or older who were providing care to a senior (Table 1). Almost three-quarters (73%) of these caregivers were aged 45 to 64, although a quarter were seniors themselves; in

The data

The data are from the 2008/2009 Canadian Community Health Survey (CCHS)–Healthy Aging, a cross-sectional survey about factors that contribute to healthy aging. Information was collected from 30,865 people aged 45 or older living in private occupied dwellings in the ten provinces. The survey excluded full-time members of the Canadian Forces and residents of the three territories, Indian reserves or Crown lands, institutions and some remote regions.

This study deals with people who reported that they provided care to a senior with a short- or long-term condition or limitation. Respondents who primarily provided care to someone younger than age 65 were excluded from this analysis. Some respondents reported caring for more than one person. The questions pertained to the person to whom, in the past 12 months, the caregiver had dedicated the most time and resources. It is possible that the caregiver who responded to the survey was not the only one providing care to that person.

Among caregivers, 11.4% were also receiving care. These respondents were included in the sample for this study, although subsequent analyses suggested that excluding them would not alter the results. The analysis represents caregivers, not care recipients; the information on care recipients is not representative of all Canadians aged 65 or older who receive care.

Descriptive statistics were used to compare caregivers with non-caregivers. Sampling weights were used in all analyses. To account for the complex survey design, a bootstrapping technique was applied for variance estimation.[10]

Caregivers were classified by age group: 45 to 54, 55 to 64, 65 to 74, and 75 or older. Their marital status was classified as married/common-law or widowed/separated/divorced/single. Household income deciles were derived by calculating the ratio between the total household income and Statistics Canada's low-income cutoff (LICO) specific to the number of people in the household, the size of the community, and the survey year. Their highest educational attainment was categorized as: less than secondary graduation, secondary graduation/some postsecondary, and postsecondary graduation. Employment data were collected only from respondents younger than age 75. Employment status was based on whether the respondent had worked in the past year.

Caregivers' self-perceived health was based on the question, "In general, would you say your health is: . . . ." Response options were: excellent, very good, good, fair or poor. Those with excellent or very good health were defined as having high self-perceived health, and those with good, fair or poor health were defined as having lower self-perceived health. A similar question was used for self-perceived mental health. Both self-perceived physical and mental health were age-standardized to account for the uneven distribution within the age categories.

The characteristics of care recipients examined in this study are age (65 to 74, 75 to 84, and 85 or older), relationship to caregiver (for example, spouse, parent or child), residence (same household, other household or institution), and nature of their health condition (short-term, long-term, other). The CCHS–Healthy Aging did not collect data on care recipients' specific health conditions.

The characteristics of the care provided are the type (transportation, help with housework, personal care, meals and other), duration (less than one year to five or more years), frequency (daily, less than daily, occasionally or rarely), and whether providing care had affected the caregiver's health.

Based on a list of response options, caregivers were asked about the positive and negative aspects of providing care.

fact, 10% of them were aged 75 or older. Even so, the age profile of caregivers was younger, compared with non-caregivers (who included care recipients), 18% of whom were 75 or older.

Perhaps reflecting their younger age profile, caregivers were more likely than non-caregivers to be married or in a common-law relationship (78% versus 71%). They were also more likely to have a higher household income and to be postsecondary graduates. Among those aged 45 to 74, caregivers were less likely than non-caregivers to have been employed in the past year.

Self-perceived health has been shown to be a reliable measure of general health status.[11] Higher percentages of caregivers than non-caregivers reported very good or excellent physical and mental health. Nonetheless, it is possible that some degree of self-selection is operating. That is, healthier people may be more capable of being caregivers, and so, more likely to undertake the task. In multivariate analyses that controlled for sex, age, household income and educational attainment, associations between high self-perceived physical and mental health and being a caregiver were no longer significant (data not shown).

Care recipients

Around three-quarters of caregivers reported that the person whom they assisted was at least 75 years old; one-third were caring for a senior aged 85 or older (Table 2).

Parents and parents-in-law made up more than half (56%) of those receiving informal care. Another 19% of caregivers reported assisting a friend or neighbour, and 11% were caring for a spouse.

Relatively few care recipients (14%) actually lived with the caregiver. A substantial majority (70%) of these care recipients were living in another private household, and 12% were in a health care institution.

Caregiving duties

Transportation was the most common form of care provided, reported by 39% of caregivers. About 20% were assisting with household activities, and around 15%, with personal care.

Although 57% of caregivers described their provision of care as "regular," this was a daily commitment for only 21% of them; 36% provided regular care once a week, once a month, or less than once a month. About a third of caregivers had been providing care for at least five years; almost as many reported that they had been doing so for less than a year.

The literature suggests that those who care for someone with severe cognitive impairment are at elevated risk of experiencing caregiver stress or burden,[5,7] but because the CCHS did not ask about the care recipients' specific health condition, this issue could not be addressed in the current study.

Table 1
Percentage distribution of selected characteristics of caregivers and non-caregivers, household population aged 45 or older, Canada excluding territories, 2008/2009

	Caregiver			Non-caregiver		
		95% confidence interval			95% confidence interval	
	%	from	to	%	from	to
Total	**100.0**	...	...	**100.0**	...	...
Sex						
Men	43.2	41.3	45.1	50.1	49.0	51.2
Women	56.8	54.9	58.7	49.9	48.8	51.0
Age group						
45 to 54	39.8	37.7	42.0	35.9	34.6	37.2
55 to 64	32.8	31.2	34.4	26.5	25.6	27.4
65 to 74	17.1	16.1	18.0	19.2	18.6	19.8
75 or older	10.3	9.6	11.1	18.4	17.9	19.0
Marital status						
Married/Common-law	77.9	76.3	79.4	71.3	70.0	72.5
Widowed/Separated/Divorced/Single	22.1	20.6	23.7	28.7	27.5	30.0
Household income decile						
1 (lowest)	5.7	5.0	6.5	12.9	11.9	14.0
2	8.1	7.2	9.2	11.5	10.6	12.4
3	9.4	8.3	10.7	10.7	9.9	11.6
4	10.2	9.0	11.6	10.5	9.6	11.5
5	10.5	9.2	12.1	9.8	8.8	10.9
6	11.1	9.9	12.6	9.2	8.2	10.3
7	10.2	9.0	11.6	8.9	7.9	10.0
8	11.0	9.4	12.8	9.5	8.3	10.9
9	12.3	10.6	14.1	8.9	7.9	10.1
10 (highest)	11.4	10.0	13.0	8.0	7.0	9.1
Education						
Less than secondary graduation	16.3	15.0	17.8	27.7	26.4	28.9
Secondary graduation or some postsecondary	25.2	23.7	26.9	24.9	23.5	26.3
Postsecondary graduation	58.4	56.5	60.3	47.5	45.8	49.1
Employment status†						
Not employed in past year	68.8	66.9	70.5	65.3	63.9	66.8
Employed in past year	31.2	29.5	33.1	34.7	33.2	36.1
Self-perceived physical health‡						
Excellent/Very good	58.0	55.9	60.0	53.2	51.4	54.9
Good/Fair/Poor	42.0	40.0	44.1	46.8	45.1	48.6
Self-perceived mental health‡						
Excellent/Very good	76.6	74.7	78.3	72.2	70.7	73.7
Good/Fair/Poor	23.4	21.7	25.3	27.8	26.3	29.3

† respondents aged 45 to 74
‡ age-standardized to account for uneven distribution within age categories
... not applicable
Source: 2008/2009 Canadian Community Health Survey–Healthy Aging.

Table 2
Percentage distribution of characteristics of care recipient and care provided, household population aged 45 or older, Canada excluding territories, 2008/2009

		95% confidence interval	
	%	from	to
Care recipient	**100.0**	...	...
Age group			
65 to 74	21.6	20.0	23.3
75 to 84	45.9	43.9	47.9
85 or older	32.5	30.6	34.6
Relationship to caregiver			
Parent/Parent-in-law	55.8	54.0	57.7
Friend/Neighbour/Other	19.2	17.8	20.7
Spouse/Common-law partner	10.5	9.5	11.6
Other relative	9.7	8.7	10.7
Child (older than age 65)	4.8	3.9	6.0
Residence			
Another household	69.6	67.7	71.4
Same household	13.6	12.3	15.0
Health care institution	12.0	10.9	13.3
Deceased†	4.8	4.1	5.6
Health condition			
Short-term	13.4	11.0	16.2
Long-term	83.5	80.7	86.0
Other	3.1	2.4	4.1
Care provided	**100.0**	...	...
Type			
Transportation	38.8	36.7	40.9
Help with activities such as housework	20.5	18.9	22.3
Personal care	15.5	14.1	17.1
Meal preparation and delivery	11.2	9.9	12.7
Other	14.0	12.6	15.5
Frequency			
Regular (daily)	21.1	19.4	23.0
Regular (less than daily)	35.5	33.5	37.6
Occasionally/Rarely	43.4	41.2	45.5
Duration			
Less than 1 year	30.2	28.1	32.5
1 to less than 3 years	21.5	19.9	23.2
3 to less than 5 years	13.8	12.5	15.2
5 or more years	34.5	32.5	36.5

† person cared for in past 12 months was deceased at time of survey
... not applicable
Source: 2008/2009 Canadian Community Health Survey–Healthy Aging.

Challenges and rewards

Although a relatively small percentage of informal caregivers reported that caregiving had caused or worsened a health problem (8%), more than half (56%) of them encountered difficulties and challenges (Table 3). When they were asked about the most negative aspect of caregiving, 17% reported that it was emotionally demanding; 12% said that because of caregiving, they did not have enough time for themselves or family; 10% said it created stress; and 7% reported fatigue.

At the same time, almost all (95%) informal caregivers reported positive aspects: 30% said that the most positive aspect of caregiving was personal satisfaction; 26% enjoyed providing assistance; and 19% stated that it made them feel closer to the care recipient.

Table 3
Percentage distribution of negative and positive aspects of caregiving, household population aged 45 or older, Canada excluding territories, 2008/2009

	%	95% confidence interval from	to
Caregiving caused/worsened caregiver's health condition	**100.0**	...	...
Yes	7.8	6.7	9.0
No	92.2	91.0	93.3
Most negative aspect	**100.0**	...	...
Emotionally demanding	17.4	15.9	18.9
Not enough time for self/family	12.0	10.5	13.5
Creates stress	9.5	8.2	11.1
Fatigue	6.6	5.5	7.8
Affects family/other relationships	2.4	1.8	3.2
Interferes with work	1.9[E]	1.4	2.7
Conflicts with social life	0.9[E]	0.6	1.3
Financial burden	0.5[E]	0.3	0.8
Other	4.5	3.6	5.5
Did not experience difficulties	44.4	42.2	46.6
Most positive aspect	**100.0**	...	...
Personal satisfaction	30.4	28.3	32.5
Enjoy providing assistance	25.8	23.9	27.8
Closer to care recipient	18.7	17.2	20.4
Feel needed	16.4	14.8	18.0
Other	3.8	3.0	4.7
No positive aspects	5.0	3.7	6.6

[E] use with caution
... not applicable
Source: 2008/2009 Canadian Community Health Survey–Healthy Aging.

Conclusion

In 2008/2009, about one-third of Canadians aged 45 or older were providing care to a senior with a short- or long-term health condition or limitation. Among the negative aspects of caregiving that they reported were that it was emotionally demanding and that it meant they did not have enough time for themselves or their family. On the other hand, substantial numbers reported that they derived personal satisfaction from caregiving and enjoyed providing assistance. ■

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Overweight and obesity in children and adolescents: Results from the 2009 to 2011 Canadian Health Measures Survey

by Karen C. Roberts, Margot Shields, Margaret de Groh, Alfred Aziz and Jo-Anne Gilbert

Abstract

Background

The 2009 to 2011 Canadian Health Measures Survey provides the most recent measured body mass index (BMI) data for children and adolescents. However, different methodologies exist for classifying BMI among children and youth. Based on the most recent World Health Organization classification, nearly a third of 5- to 17-year-olds were overweight or obese. The prevalence of obesity differed between boys and girls (15.1% versus 8.0%), most notably those aged 5 to 11, among whom the percentage of obese boys (19.5%) was more than three times that of obese girls (6.3%). These estimates indicate a higher prevalence of overweight/obesity among children than do estimates based on International Obesity Task Force cut-offs. Although the prevalence of overweight and obesity among children in Canada has not increased over the last decade, it remains a public health concern, given the tendency for excess weight to persist through to adulthood and lead to negative health outcomes.

Keywords

Body mass index, child, adolescent, population surveillance

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Since the late 1970s, the prevalence of overweight and obesity has risen among children and adolescents in Canada.[1] Excess weight in childhood has been linked to insulin resistance, type 2 diabetes, hypertension, poor emotional health, and diminished social well-being.[2,3] As well, obese children tend to become obese adults, making childhood obesity a public health concern.[4-6]

Routine surveillance of overweight and obesity is important for the development and assessment of efforts aimed at reducing excess weight in children and adolescents. The most common approach to classifying weight is the body mass index (BMI), which estimates adiposity based on weight relative to height.[7-10] The use of measured, rather than reported, height and weight to derive BMI is strongly recommended, especially for children and adolescents.[11]

Since the Canada Health Survey (age 0 and up) in 1978/1979, only a few national population-level surveys have directly measured the height and weight of children and adolescents: the 1981 Canada Fitness Survey (age 7 or older), the 1988 Campbell's Survey on the Well-being of Canadians (age 7 or older), the 2004 Canadian Community Health Survey (CCHS), Cycle 2.2 Nutrition (age 2 or older), and the 2007 to 2009 Canadian Health Measures Survey (CHMS) (age 6 or older). The most recent CHMS cycle (2009 to 2011) included children aged 3 or older.

BMI classification guidelines for adults have been in place for decades,[9] with cut-offs for specific categories based on scientific evidence of increasing health risks with increased BMI. Establishing a standard BMI classification system for children has been more challenging, because of variations in growth rates and the difficulty of linking estimated adiposity levels in childhood to weight-related health outcomes that tend to manifest later in life. A number of classification systems for use at the population level have been developed to estimate overweight and obesity in children.[12] Since 2004, Canada has used the age-/sex-specific classification cut-offs established by the International Obesity Task Force (IOTF).[13,14] In 2007, the World Health Organization (WHO) released a new set of age-/sex-specific

The data

Estimates are based on data from the second cycle (2009 to 2011) of the Canadian Health Measures Survey (CHMS). The CHMS is an ongoing survey designed to provide comprehensive direct health measures data at the national level.[15] Ethics approval was obtained from Health Canada's Research Ethics Board.[16] The 2009 to 2011 CHMS covered the population aged 3 to 79 in private households. It excluded residents of Indian Reserves, institutions and some remote regions, and full-time members of the regular Canadian Forces. More than 96% of the population aged 3 to 79 is represented.[17]

Data were collected at 18 sites across Canada from August 2009 to December 2011. In addition to a questionnaire administered in the respondent's home, the survey involved physical measures (including height and weight) in a mobile examination centre. Participation was voluntary. Written informed consent was obtained from respondents aged 14 or older. For younger children, a parent or legal guardian provided written consent, in addition to written assent from the child (where possible). The *CHMS Cycle 2 Data User Guide*[17] contains details about the 2009 to 2011 survey content and sample design.

Of the households selected for the survey, 75.9% agreed to participate. In each responding household, one or two members were selected: 90.5% of selected household members completed the household questionnaire, and 81.7% of the responding household members participated in the subsequent physical measures component. The final response rate, after adjusting for the sampling strategy, was 55.5%.[17] This article is based on 2,123 respondents aged 5 to 17, for whom measured values of height and weight were collected.

Height was measured to the nearest 0.1 centimetre using a ProScale M150 digital stadiometer (Accurate Technology Inc., Fletcher, USA), and weight, to the nearest 0.1 kilogram with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Canada).

Body mass index was derived as weight in kilograms divided by height in metres squared. Based on BMI, children and adolescents were classified according to thinness, normal weight, overweight or obesity using two sets of age- and sex-specific cut-offs, one set specified by the WHO,[18] and the other, by the IOTF.[13,14]

The WHO cut-off criteria used to classify children younger than age 5 as overweight or obese[19] differ slightly from those used for children aged 5 or older,[18] and the WHO does not recommend combining across age groups. Because the sample size for 3- and 4-year-old children in the 2009 to 2011 CHMS was too small to provide reliable estimates using these cut-offs, this age group was not included in this report.

All estimates were based on weighted data. Statistical analyses were performed using SAS and SUDAAN software. Standard errors, coefficients of variation and 95% confidence intervals were calculated with the *bootstrap* technique.[20,21] The number of degrees of freedom was specified as 13 to account for the 2009 to 2011 CHMS sample design.[17] Significance levels were set at $p < 0.05$.

Table 1
Percentage distribution of children and adolescents, by body mass index (BMI) category (based on World Health Organization cut-offs), age group and sex, household population aged 5 to 17, 2009 to 2011

	Thinness			Normal weight			Overweight			Obesity		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
	%	from	to	%	from	to	%	from	to	%	from	to
Total	2.2[E]	1.1	4.1	66.4	62.8	69.8	19.8	16.6	23.4	11.7	9.9	13.7
Age group (years)												
5 to 11	F	...	...	65.5	61.7	69.2	19.7	16.4	23.4	13.1	10.5	16.3
12 to 17	F	...	...	67.2	60.2	73.6	19.9	15.0	25.8	10.2	7.3	14.1
Boys	F	...	...	62.3	56.3	68.0	19.4	15.1	24.4	15.1	12.6	17.9
Age group (years)												
5 to 11	F	...	...	59.0	51.9	65.7	19.8	14.8	26.0	19.5	15.5	24.1
12 to 17	F	...	...	65.6	55.3	74.6	18.9[E]	12.6	27.5	10.7*	7.5	15.0
Girls	1.0[E]	0.6	1.6	70.8	64.6	76.3	20.2	15.8	25.6	8.0†	5.7	11.1
Age group (years)												
5 to 11	1.5[E]	0.7	3.1	72.6†	69.8	75.2	19.6	16.1	23.6	6.3†[E]	4.1	9.8
12 to 17	F	...	...	69.0	58.5	77.9	20.9	14.9	28.6	9.6[E]	6.0	15.1

* significantly different from ages 5 to 11 ($p<0.05$)
† significantly different from boys ($p<0.05$)
E use with caution
F too unreliable to be published
... not applicable
Source: 2009 to 2011 Canadian Health Measures Survey.

Table 2
Percentage distribution of children and adolescents, by body mass index category based on World Health Organization (WHO) and International Obesity Task Force (IOTF) cut-offs, age group and sex, household population aged 5 to 17, 2009 to 2011

	Thinness						Normal weight						Overweight						Obesity					
	WHO			IOTF			WHO			IOTF			WHO			IOTF			WHO			IOTF		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
Characteristics	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to
Total	**2.2[E]**	**1.1**	**4.1**	**1.6[E]**	**0.8**	**3.2**	**66.4**	**62.8**	**69.8**	**73.6**	**69.7**	**77.3**	**19.8**	**16.6**	**23.4**	**16.4**	**13.4**	**19.9**	**11.7**	**9.9**	**13.7**	**8.4**	**6.8**	**10.2**
Age group (years)																								
5 to 11	F	...	...	1.0[E]	0.5	1.9	65.5	61.7	69.2	76.4	72.6	79.9	19.7	16.4	23.4	14.7	12.1	17.9	13.1	10.5	16.3	7.9	5.8	10.5
12 to 17	F	...	...	F	...	...	67.2	60.2	73.6	70.9	63.9	77.0	19.9	15.0	25.8	18.0	13.8	23.1	10.2	7.3	14.1	8.9	6.3	12.3
Sex																								
Boys	F	...	...	F	...	...	62.3	56.3	68.0	72.7	65.8	78.6	19.4	15.1	24.4	15.8	11.7	21.1	15.1	12.6	17.9	9.5	7.4	12.2
Girls	1.0[E]	0.6	1.6	1.2[E]	0.7	2.2	70.8	64.6	76.3	74.7	68.7	79.9	20.2	15.8	25.6	17.0	13.0	21.8	8.0*	5.7	11.1	7.1	5.0	10.0

* significantly different from boys (p<0.05)
[E] use with caution
F too unreliable to be published
... not applicable
Source: 2009 to 2011 Canadian Health Measures Survey.

classification cut-offs for children and adolescents aged 5 to 19.[18]

Although the IOTF classification has been used extensively, a systematic review has found that it underestimates obesity.[22] Furthermore, the IOTF classification is only appropriate for use at the population level and cannot be used to assess excess weight at the individual level.[13] The WHO growth charts[18] have gained acceptance for use at the individual level, and in 2010, key professional associations recommended that health care professionals employ them to monitor the growth of Canadian children.[23] Adaptation and implementation of the WHO growth charts is underway in several jurisdictions (for example, British Columbia, Alberta, Saskatchewan, Yukon, New Brunswick and Nova Scotia).[24] Estimating overweight and obesity based on the WHO growth references ensures that the methods used to determine excess weight in children and adolescents are consistent at the individual and population levels.

With measured height and weight data from the 2009 to 2011 CHMS, this report presents population estimates of overweight and obesity among Canadian children and adolescents based on the WHO cut-off values and compares them with the IOTF thresholds (see *The data*).

Obesity prevelance

According to the WHO approach, close to one third (31.5%) of 5- to 17-year-olds, an estimated 1.6 million, were classified as overweight (19.8%) or obese (11.7%) in 2009 to 2011 (Table 1). The percentage who were overweight was similar across age groups. However, the prevalence of obesity differed between boys and girls (15.1% versus 8.0%), most notably at ages 5 to 11, among whom the percentage of boys who were obese (19.5%) was more than three times the percentage of girls who were obese (6.3%) (Table 1).

WHO versus IOTF approaches

The WHO cut-offs identified a greater percentage of children as overweight or obese than did the IOTF cut-offs: 31.5% versus 24.8% (Table 2). At ages 5 to 11, the difference was more pronounced than at ages 12 to 17. According to the WHO cut-offs, an estimated 32.8% of 5- to 11-year-olds were overweight or obese, compared with an estimated 22.6% based on the IOTF cut-offs.

Table 3
Mean body mass index (BMI) and percentage distribution by BMI category (based on World Health Organization cut-offs) of children and adolescents, household population aged 6 to 17, 2004, 2007 to 2009, and 2009 to 2011

	2004			2007 to 2009			2009 to 2011		
		95% confidence interval			95% confidence interval			95% confidence interval	
Characteristics		from	to		from	to		from	to
Mean BMI	20.19	20.03	20.35	20.09	19.55	20.63	20.03	19.67	20.40
BMI category (%)									
Thinness	1.4[E]	1.0	2.0	1.6[E]	0.8	3.2	2.3[E]	1.2	4.5
Normal weight	63.8	61.9	65.7	66.4	60.4	71.9	66.6	62.7	70.3
Overweight	21.4	19.9	23.1	17.7	13.9	22.2	19.5	15.9	23.6
Obesity	13.3	12.1	14.7	14.3	11.5	17.5	11.6	9.8	13.7

[E] use with caution
Note: There are no significant differences over time.
Source: 2004 Canadian Community Health Survey -- Nutrition; 2007 to 2009 Canadian Health Measures Survey; 2009 to 2011 Canadian Health Measures Survey.

A comparison of the classification systems showed that 72% of the children classified as obese based on the WHO approach would also be classified as obese based on the IOTF approach; the remaining 28% would be classified as overweight. Likewise, 66% of the children classified as overweight based on the WHO approach would also be classified as overweight based on the IOTF approach; the remaining 34% would be classified as normal weight.

The higher prevalence of obesity observed using the WHO approach is consistent with previous reports.[12,25] In a summary of the results of a number of studies, Reilly et al. noted that many of them demonstrated that the IOTF classification underestimates the prevalence of excess weight, particularly obesity, in children and adolescents.[22]

No significant differences were observed in the estimates of overweight and obesity among children and adolescents aged 6 to 17 when data from the 2004 CCHS, the 2007 to 2009 CHMS, and the 2009 to 2011 CHMS were compared using the WHO cut-offs (Table 3) or IOTF cut-offs (data not shown).

This analysis concerns only one measure of adiposity—BMI. A recent Canadian study[26] showed that over time, waist circumference among Canadians of all ages has increased more than BMI. Evidence for adults indicates that changes in the distribution of body fat, such as increases in waist circumference, are associated with elevated health risk,[27] and suggests that even if the population prevalence of BMI does not change, changes in the distribution of body fat may increase health risk.[26]

Conclusion

The factors associated with overweight and obesity are complex,[7] and include health behaviours, such as eating habits and daily physical activity, and broader social, environmental and biological determinants that influence these health behaviours.[28,29] However, the sample size did not permit examination of trends in rates by these characteristics.

The 2009 to 2011 CHMS provides the most recent BMI data, based on measured height and weight, for children and adolescents in Canada. According to the WHO approach, close to a third of 5- to 17-year-olds were identified as overweight or obese, compared with about a quarter according to the IOTF cut-offs. Classification differences between approaches were greatest at ages 5 to 11. Although these estimates have not changed significantly in recent years, more data points are needed to determine if the pace of increase in prevalence is slowing, as has been observed in some countries.[30] Regardless, the estimates remain high and are a public health concern, given the tendency for excess weight in childhood to persist through to adulthood. ■

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Area-based methods to calculate hospitalization rates for the foreign-born population in Canada, 2005/2006

by Gisèle Carrière, Paul A. Peters and Claudia Sanmartin

Abstract

Background
Hospital records lack information about country of birth. This study describes a method for calculating hospitalization rates by the percentage of foreign-born in Census Dissemination Areas (DAs).

Data and methods
Data from the 2006 Census were used to classify DAs by the percentage of the foreign-born population who lived in them. Quintile and tercile thresholds were created to classify DAs as having low to high percentages of foreign-born residents. This information was appended to the 2005/2006 Hospital Morbidity Database via postal codes. Age-sex standardized hospitalization rates were calculated for low to high foreign-born concentration DAs, nationally and subnationally.

Results
Nationally, quintile thresholds had better discriminatory power to detect variations in hospitalization rates by foreign-born concentration, but tercile thresholds produced reliable results at subnational levels. All-cause hospitalization rates were lowest among residents of the high foreign-born concentration terciles. Similar gradients emerged in hospitalization rates for heart disease, diseases of the circulatory system, and mental health conditions. The pattern varied more at the subnational level.

Interpretation
With this approach, administrative data can be used to calculate hospitalization rates by foreign-born concentration.

Keywords
Administrative data, ecological studies, hospital records, immigration, public health surveillance

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By 2031, it is projected that 28% of Canada's population could be foreign-born, up from about 20% in 2006.[1] Understanding patterns of health care use among this growing segment of the population is important for the planning and delivery of services. While evidence suggests better health among the foreign-born compared with people born in Canada,[2-9] much of that research is based on survey data.[3-6, 10,11] Those studies are typically constrained by small sample sizes that limit area-level comparisons. Furthermore, analysis based on survey data may be subject to recall bias or affected by linguistic and cultural barriers.

Hospital administrative records cover all acute-care hospitalizations and allow analysis at detailed levels of geography. However, these records do not contain information about patients' country of birth and immigration status. In the absence of individual-level information, area-based methods can be applied to study hospital use patterns for areas with high concentrations of foreign-born individuals. Such approaches have been used in Canada to analyze health outcomes by neighbourhood socio-economic status and concentration of the Aboriginal population.[12-14]

Because immigrants have tended to settle in large urban areas,[15] and because the concentration of the foreign-born has increased over time,[16-18] area-based methods can be applied to study hospitalization patterns in areas with high concentrations of foreign-born individuals. While hospital data for specific regions have been linked to immigration data,[2] such work has not been undertaken at the national level.

This study describes an area-based method of calculating standardized, comparable hospitalization rates for areas with varying concentrations of

foreign-born, at national and subnational levels.[19] Based on previous research,[2-7] the hypothesis is that hospitalization rates are likely to be lower in areas with high percentages of foreign-born residents.

Methods

Data sources

Counts of the foreign-born population are from the 2006 Census long-form questionnaire, which was administered to 20% of households (non-institutionalized population). The information collected in the questionnaire included country of birth, immigrant status, and socio-economic and demographic characteristics.

Hospitalization data are from the Hospital Morbidity Database, which covers all inpatient acute-care hospital discharges in Canada. The data are compiled by the Canadian Institute of Health Information. Hospital records from fiscal year 2005/2006 (April 1, 2005 through March 31, 2006) were used because they are closest in time to the census year. These records contain medical information such as diagnoses and procedures, and patient information such as date of birth, sex, and importantly for this analysis, postal codes. Six-character postal codes are available for all provinces/territories except Quebec, for which only the first three characters are provided.

Definition of foreign-born

In this study, "foreign-born" refers to those who either (1) ever held the legal status of immigrant to Canada, or (2) were non-permanent residents (NPRs). NPRs are people from another country who, at the time of the census, held a work or study permit or were refugee claimants, or who had applied for landed immigrant status but had not yet been accepted, as well as family members living with them in Canada.[20] From a health perspective, NPRs more closely resemble immigrants than people born in Canada, so they are combined with immigrants to represent the foreign-born. In 2006, NPRs made up 4% of the foreign-born population, and less than 1% of the total Canadian population.

Level of geography

This analysis requires that areas with high percentages of foreign-born residents be distinguished from areas with low percentages of foreign-born residents. A small geographic unit is needed because population homogeneity across an area tends to increase with geographic size,[21] thereby diluting associations between foreign-born concentration and hospitalization rates.

To some extent, the foreign-born population in Canada is spatially concentrated. Immigrants tend to settle in Census Metropolitan Areas (CMAs), such as Toronto and Vancouver,[15] and many remain in these "gateway" cities.[22]

This analysis is based on Dissemination Areas (DAs), the smallest level of geography (400 to 700 residents) for which aggregate census information is available.[23] In 2006, DAs totalled 54,626; aggregate information about population characteristics was available for 92% of them (50,214).

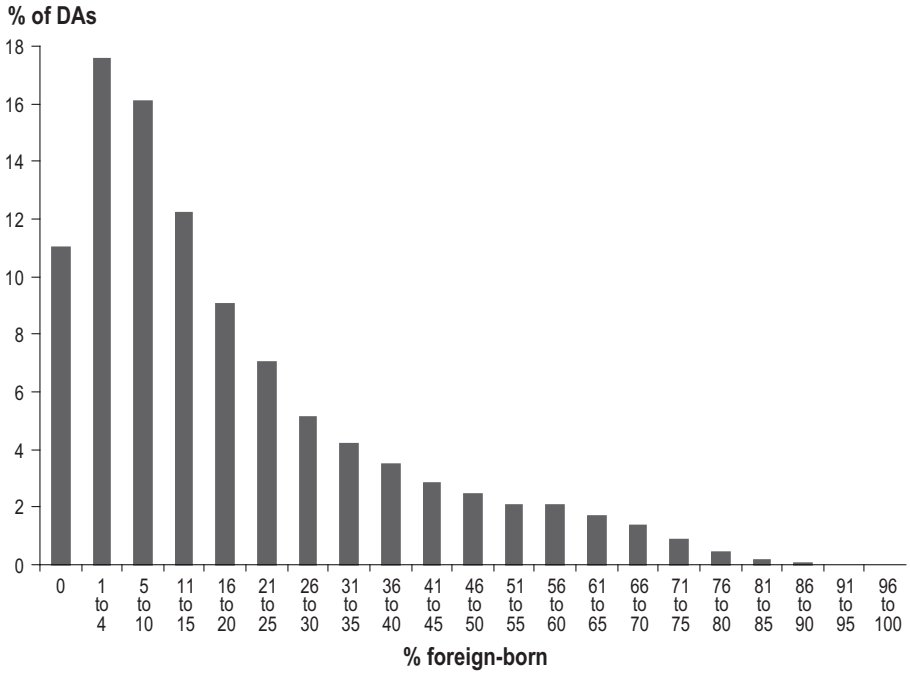
Development of area-based measure of foreign-born

Development of an area-based measure of foreign-born concentration involves three steps: 1) calculation of foreign-born population concentrations; 2) selection of the base population to measure the distribution of concentration values; and 3) selection of a quantile to delineate thresholds that will be used to classify areas according to their foreign-born concentration.

Calculation of foreign-born population concentration

Foreign-born *concentration* is the percentage of individuals in each DA in 2006 who were foreign-born. In 45% of DAs, no more than 10% of the population were foreign-born, on the other hand, in about 9% of DAs, at least 50% of the population were foreign-born (Figure 1).

Figure 1
Distribution of Dissemination Areas (DAs), by percentage foreign-born in DA population, Canada, 2006



Note: Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population.

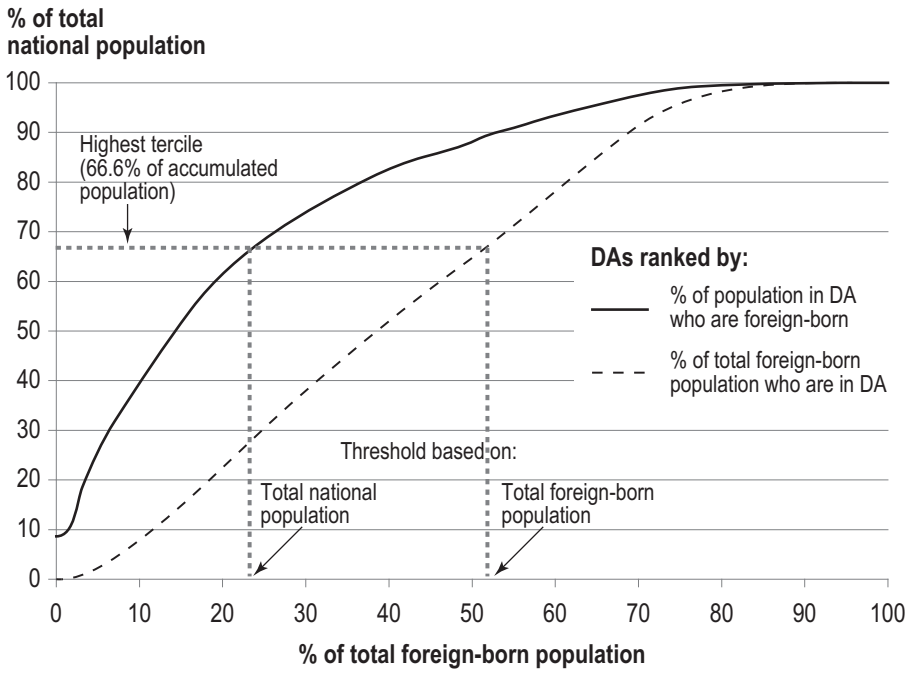
Selection of base population

To establish concentration thresholds, all DAs across Canada were ordered from lowest to highest DA percentage of foreign-born. Next, this percentage foreign-born (the DA measure) was distributed across each of two possible base populations: the total national population and the total foreign-born population. By distributing the percentage foreign-born measure this way, a specific foreign-born percentage value could be discerned to divide the base population into a given quantile, for example, thirds (terciles) or fifths (quintiles). The foreign-born population is preferred as the base population because the resulting thresholds that define any given quantile contain greater foreign-born concentrations than do thresholds derived if the total national population had been used as the base. The advantage of using the foreign-born population as the base population is illustrated in Figure 2. If the total national population is used as the base population, thresholds that delineate areas that contain terciles of the total population show that the highest tercile (where 66.6% of the national population has accumulated) cut-off occurs when the percentage foreign-born DA measure is equal to 24%. That is, DAs in which at least 24% of the population are foreign-born would be considered "high concentration of foreign-born." However, thresholds that delineate areas containing thirds of the *foreign-born* population yield a "high-concentration" cut-off of 52% foreign-born. Given these results, the distribution of the percentage foreign-born across the foreign-born population was used to establish thresholds to classify each DA.

Selection of quantile

The choice of quantiles (thirds or fifths of the foreign-born) to set foreign-born concentration thresholds for classifying DAs was based on two criteria: 1) the range of percentage foreign-born within a given quantile; and 2) the feasibility of calculating hospitalization rates at national and sub-national (provincial/regional/territories or CMA) levels.

Figure 2
Cumulative distribution of percentage foreign-born in Dissemination Areas (DAs), by percentage of total national or total foreign-born population, Canada, 2006



Note: Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population.

Because admission to hospital is a relatively rare event—on average, fewer than one person in ten is hospitalized in any year—population counts must be large enough to produce stable estimates.

Thresholds for terciles and quintiles are presented in Table 1. By definition, each level of either quantile contains approximately equal numbers of the foreign-born: about 2.1 million in each tercile, and about 1.3 million in each quintile. All DAs across Canada were ordered from lowest to highest percentage of the foreign-born population in each, and the foreign-born population was then classified into terciles and quintiles. While the absolute *number* of foreign-born individuals is the same in each level of a quantile, the *percentage* of the total population in each level who are foreign-born (concentration) varies. For example, while approximately 2.1 million foreign-born are in each tercile, they make up 9.8% of the total population in the "low-concentration" tercile, but 63.7% of the total population in the "high-concentration" tercile.

For the *quintile* thresholds, quintile 1 (lowest foreign-born concentration) consists of DAs in which the percentage of the population who were foreign-born was 19.0% or less; quintile 5 (highest foreign-born concentration) consists of DAs in which the percentage of the population who were foreign-born was more than 62.0%. The percentage of the population who were foreign-born in the lowest *tercile* is less than 27.0%, and in the highest, more than 51.8%.

Hospitalization rates were calculated based on quintiles and terciles (Table 1). Quintile-based thresholds result in better discrimination of national all-cause hospitalization rate differences between the highest and lowest quantiles (rate ratio=0.64) than do tercile-based thresholds (rate ratio=0.69). For both quantiles, 95% confidence intervals

Table 1
Age-sex standardized all-cause hospitalization rates (per 10,000), by quantile of percentage of foreign-born population, Canada, 2005/2006

Foreign-born concentration quantile	Foreign-born Number	Foreign-born % of quantile population	% foreign-born range	Hospitalization rate	95% confidence interval from	95% confidence interval to	Rate ratio	95% confidence interval from	95% confidence interval to
Canada	**6,377,250**	**20.8**	**...**	**753.0**	**752.0**	**753.9**	**...**	**...**	**...**
Quintile									
1 (lowest)	1,282,165	7.1	19.0 or less	840.7	839.4	842.0	1.00	..	..
2	1,270,545	24.4	More than 19.0 to 32.0	663.8*	661.6	666.0	0.79	0.79	0.79
3	1,277,825	38.3	More than 32.0 to 46.0	621.8*	619.1	624.5	0.74	0.74	0.74
4	1,278,465	53.8	More than 46.0 to 62.0	586.7*	583.6	589.9	0.70	0.69	0.70
5 (highest)	1,268,250	69.8	More than 62.0	539.0*	536.4	543.5	0.64	0.64	0.65
Tercile									
1 (lowest)	2,124,740	9.8	27.0 or less	814.0	812.9	815.2	1.00	...	...
2	2,137,055	37.6	More than 27.0 to 51.8	621.9*	619.8	623.9	0.76	0.76	0.77
3 (highest)	2,115,455	63.7	More than 51.8	558.5*	555.9	561.2	0.69	0.68	0.69
Selected Census Metropolitan Areas†									
Total	4,600,320	34.1	...	616.2	614.9	617.6	...	...	...
1 (lowest)	814,030	14.0	27.0 or less	655.4	653.3	657.5	1.00	...	...
2	1,708,150	38.7	More than 27.0 to 51.8	607.9*	605.6	610.3	0.93	0.92	0.93
3 (highest)	2,078,140	63.9	More than 51.8	555.4*	552.8	558.1	0.85	0.84	0.85

† Halifax, Montreal, Toronto, Hamilton, Winnipeg, Calgary, Vancouver
* significantly different from lowest foreign-born concentration quantile (p<0.05)
... not applicable
Notes: Excludes pregnancy-related conditions. Rates are age-sex standardized to 2006 national population. Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population; 2005/2006 Hospital Morbidity Database.

indicate that the national hospitalization rates were stable. However, at the sub-national level (province/region/territory and CMA), rates were less stable (wider confidence intervals) based on quintiles than on terciles, particularly for areas with smaller populations (total and foreign-born). For example, in Alberta, hospitalization rates produced using tercile thresholds had a smaller standard error for areas with the highest foreign-born concentration than did rates produced using quintile thresholds (data not shown). As a result, the tercile measure was selected for this analysis.

Criteria for immigrant concentration within DAs could also be defined at the sub-national level (provincial/regional or CMA) to produce jurisdiction-specific thresholds. These would be more sensitive to the spatial distribution of immigrants within each jurisdiction. Jurisdiction-specific terciles were created for provinces/regions and selected CMAs. A comparison of threshold levels revealed significant variation in the definition of high, medium and low concentration of immigrants. For example, thresholds for including DAs in the high foreign-born concentration tercile range from a low of 10.7% in the Atlantic Region to a high of 57.8% in Ontario (data not shown), whereas the nationally derived threshold is 51%. This variation limits the ability to compare hospitalization rates across jurisdictions within similar terciles owing to cross-classification of DAs. For example, DAs with 25% foreign-born would be considered medium-concentration in some areas, but high-concentration in others. Because the objective of this study is to produce nationally comparable results for each level of geography, the analyses are based on nationally defined terciles.

Table 2
Age-sex standardized all-cause hospitalization rates (per 10,000), by selected causes and foreign-born concentration tercile, Canada, 2005/2006

Foreign-born concentration tercile	Circulatory diseases Rate	Circulatory diseases 95% confidence interval from	Circulatory diseases 95% confidence interval to	Heart conditions Rate	Heart conditions 95% confidence interval from	Heart conditions 95% confidence interval to	Mental health and behavioural disorders Rate	Mental health and behavioural disorders 95% confidence interval from	Mental health and behavioural disorders 95% confidence interval to
Canada	**120.1**	**119.7**	**120.5**	**66.9**	**66.6**	**67.2**	**50.7**	**50.4**	**50.9**
Low foreign-born	128.4	128.0	128.9	71.5	71.2	71.9	54.7	54.3	55.0
Medium foreign-born	100.0*	99.2	100.8	54.9*	54.3	55.5	43.8*	43.3	44.4
High foreign-born	93.4*	92.3	94.5	53.2*	52.4	54.1	37.1*	36.4	37.7

* significantly different from low foreign-born concentration tercile (p<0.05)
Note: Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population; 2005/2006 Hospital Morbidity Database.

Applying the area-based measure to hospital data

Using the PCCF+ application developed at Statistics Canada, a 2006 Census DA code was assigned to each hospital separation record based on the patient's residential postal code.[24,25] The DA code was used to classify each hospital record into a foreign-born concentration tercile.

Causes of hospitalization were determined from the "most responsible diagnosis" (excluding pregnancy-related) coded either to the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada* (ICD-10)[26] or to the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9)[27] for Quebec. The following cause-specific hospitalizations were defined: circulatory system diseases; selected heart conditions (heart failure, pulmonary edema; ischemic heart disease including acute myocardial infarction); and mental and behavioural disorders. These causes were chosen for analysis because earlier research reported differences in the prevalence between ethnic minority populations and other Canadians,[11] and because of the need for information about the mental health of immigrants.[28]

Hospitalization rates were calculated as the number of hospitalizations per 10,000 population in DAs with high, medium or low percentages of foreign-born residents. The number of hospital separations and the corresponding population denominators are shown in Appendix Table A for Canada and by province/region/territory and selected CMAs, based on nationally defined foreign-born concentration terciles. No DAs in the Atlantic Region had a "high" concentration of foreign-born residents. In Saskatchewan, fewer than 700 people were in the high foreign-born concentration tercile.

Rates were standardized to the age and sex structure of the 2006 population of Canada using the direct method. Age-sex standardized rates and 95% confidence intervals were calculated for Canada, for each province/region/territory, and for selected CMAs. Confidence intervals for the standardized rates used methods derived from Spiegelman.[29]

Table 3
Age-sex standardized all-cause hospitalization rates (per 10,000), by province/region/territory and foreign-born concentration tercile, Canada, 2005/2006

Province/Region/Territory and foreign-born concentration tercile	Hospitalization rate	95% confidence interval from	95% confidence interval to	Rate ratio
Canada	**753.0**	**752.0**	**753.9**	**...**
Atlantic	**931.2**	**927.4**	**935.2**	**...**
Low foreign-born	931.0	927.1	934.9	1.00
Medium foreign-born	965.4	903.6	1,031.4	1.04
High foreign-born	...	...	...	...
Quebec	**717.9**	**716.0**	**719.8**	**...**
Low foreign-born	742.2	740.1	744.3	1.00
Medium foreign-born	597.6*	592.6	602.6	0.81
High foreign-born	592.2*	583.5	601.0	0.80
Ontario	**698.3**	**696.8**	**699.8**	**...**
Low foreign-born	773.4	771.3	775.4	1.00
Medium foreign-born	620.6*	617.7	623.5	0.80
High foreign-born	560.9*	557.7	564.1	0.73
Manitoba	**813.6**	**808.3**	**818.9**	**...**
Low foreign-born	835.5	829.7	841.3	1.00
Medium foreign-born	679.5*	666.3	692.9	0.81
High foreign-born	703.5*	645.7	766.5	0.84
Saskatchewan	**1,059.0**	**1,052.5**	**1,065.5**	**...**
Low foreign-born	1,059.1	1,052.6	1,065.7	1.00
Medium foreign-born	1,111.2	1,035.5	1,192.4	1.05
High foreign-born†	F	F	F	F
Alberta	**846.0**	**842.7**	**849.4**	**...**
Low foreign-born	898.3	894.5	902.2	1.00
Medium foreign-born	632.9*	626.0	639.9	0.70
High foreign-born	617.2*	592.4	643.1	0.69
British Columbia	**709.0**	**706.4**	**711.6**	**...**
Low foreign-born	807.1	803.4	810.7	1.00
Medium foreign-born	616.6*	612.1	621.2	0.76
High foreign-born	518.3*	512.6	524.0	0.64
Territories and Nunavut	**990.3**	**962.7**	**1,018.7**	**...**
Low foreign-born	990.3	962.7	1,018.7	1.00
Medium foreign-born	...	...	...	...
High foreign-born	...	...	...	...

† based on one Dissemination Area (population of 695) and 13 hospitalizations; use with caution
* significantly different from low foreign-born concentration tercile (p<0.05)
F too unreliable to be published
... not applicable
Notes: Excludes pregnancy-related conditions. Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population; 2005/2006 Hospital Morbidity Database.

Results

The national all-cause acute-care hospitalization rate was lowest among residents of DAs in the high foreign-born concentration tercile (559 hospitalizations per 10,000 population), and highest among residents of DAs in the low foreign-born concentration tercile (814 hospitalizations per 10,000 population) (Table 1). This pattern persisted for hospitalizations due to circulatory system diseases, selected heart conditions, and mental and behavioural disorders (Table 2).

Patterns in Ontario, Alberta and British Columbia were similar to the national level, with lower hospitalization rates among residents of areas classified in the high or medium foreign-born

Table 4
Age-sex standardized all-cause hospitalization rates (per 10,000), by selected Census Metropolitan Area (CMA) and foreign-born concentration tercile, Canada, 2005/2006

CMA and foreign-born concentration tercile	Hospitalization rate	95% confidence interval from	95% confidence interval to	Rate ratio
Selected CMAs	**616.2**	**614.9**	**617.6**	...
Vancouver	**596.8**	**593.4**	**600.1**	...
Low foreign-born	684.6	677.5	691.9	1.00
Medium foreign-born	602.7*	597.7	607.7	0.88
High foreign-born	516.1*	510.4	521.8	0.75
Calgary	**660.5**	**655.2**	**665.9**	...
Low foreign-born	678.2	671.6	685.0	1.00
Medium foreign-born	634.6*	625.1	644.2	0.94
High foreign-born	553.9*	527.2	581.9	0.82
Toronto	**587.9**	**585.7**	**590.1**	...
Low foreign-born	639.4	634.0	644.8	1.00
Medium foreign-born	596.7*	593.2	600.3	0.93
High foreign-born	559.0*	555.8	562.3	0.87
Montreal	**633.6**	**631.0**	**636.2**	...
Low foreign-born	653.0	649.7	656.3	1.00
Medium foreign-born	595.9*	590.9	600.9	0.91
High foreign-born	594.4*	585.6	603.2	0.91
Halifax	**612.8**	**604.6**	**621.0**	...
Low foreign-born	613.2	605.0	621.6	1.00
Medium foreign-born	576.0	509.2	651.6	0.94
High foreign-born	...	...	...	...
Hamilton	**690.2**	**684.2**	**696.4**	...
Low foreign-born	690.9	683.2	698.7	1.00
Medium foreign-born	691.3	681.0	701.7	1.00
High foreign-born	699.1	656.3	744.8	1.01
Winnipeg	**643.6**	**637.7**	**649.6**	...
Low foreign-born	638.1	631.5	644.8	1.00
Medium foreign-born	661.8*	648.3	675.6	1.04
High foreign-born	689.8	632.7	752.1	1.08

* significantly different from low foreign-born concentration tercile (p<0.05)
... not applicable
Notes: Excludes pregnancy-related conditions. Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population; 2005/2006 Hospital Morbidity Database.

Why is this study important?

- A growing percentage of the Canadian population is foreign-born.
- Understanding the health and health services use patterns of this population is increasingly important.
- Administrative health data typically do not contain information about country of birth.

What is already known on this subject?

- In the absence of individual-level information, ecological methods have been applied to understand patterns of hospital use among areas having greater or lesser percentages of subpopulations.

What this study adds

- Hospital records that lack information on country of birth can be analysed with aggregate census data to compare hospitalization rates for areas with greater or lesser percentages of foreign-born residents.
- Hospitalization rates tend to be lowest among residents of areas with a high percentage of foreign-born residents.

concentration terciles, compared with residents of areas in the low foreign-born concentration tercile (Table 3). In Quebec and Manitoba, hospitalization rates for residents of the medium and high foreign-born terciles differed significantly from each other (data not shown), and both differed significantly from the low foreign-born concentration tercile. As well, in Manitoba, the lowest hospitalization rate was among residents of the medium foreign-born concentration tercile.

All-cause hospitalization rates by foreign-born concentration also varied across CMAs (Table 4). The national pattern prevailed in Vancouver, Calgary, Toronto, and to a lesser extent, Montreal—the lowest hospitalization rates were among residents of areas classified in the high foreign-born concentration tercile. Differences across terciles were not significant in Hamilton or Halifax.

Discussion and limitations

This study demonstrates how an area-based method can be used to examine hospitalization rates in areas with high versus low percentages of foreign-born residents. The approach yields comparable information at national and sub-national levels.

Research generally suggests that it would be reasonable to expect lower hospitalization rates (excluding pregnancy-related) in areas with high percentages of foreign-born residents. Individual-level data show better self-reported health, lower prevalence of chronic conditions, lower age-specific mortality risks, and longer life expectancy among immigrants compared with the

Canadian-born.[3,7,9,30] The distribution of hospitalization rates in this analysis supports that expectation.

Differences in hospitalization rates between high and low foreign-born concentration terciles should be interpreted in the context of area characteristics, including the composition of the foreign-born population (region or country of birth). Recent studies have reported differences in health status by country of birth and time since immigration.[6-8] As well, some segments of the foreign-born may be at higher risk of hospitalization than are others because of poorer health and higher rates of chronic disease.[4,7,9,11,31,32] Given this evidence, differences in the composition of the foreign-born population are relevant in interpreting differences in hospitalization rates across immigrant terciles. For example, in 2006, more than 70% of immigrants in Vancouver reported that their country of birth was in Asia, compared with 31% of those in Montreal. In Montreal, more than 25% of immigrants reported being of Africa origin, higher than any other jurisdiction in Canada.[23] Differences in the composition of the foreign-born populations may explain variations in the gradient of hospitalization rates across jurisdictions. The steeper gradient between high and medium tercile hospitalization rates in Vancouver than in Montreal, for example, may be due to the higher percentage of Asian-born immigrants in Vancouver. Other area-level factors that have been found to be associated with higher rates of hospitalization include low-income and a high concentration of Aboriginal peoples.[33]

A key limitation of this study is that the hospitalization rates cannot be regarded as rates for foreign-born and non-foreign-born individuals per se, but rather, as rates among people living in areas with varying concentrations of the foreign-born. The analysis suggests an association between hospitalization and percentages of foreign-born in the population, but does not allow for causal inferences.

Furthermore, the hospital discharge records that Statistics Canada receives from Quebec contain only the first three characters of the postal codes. PCCF+ uses population weights to probabilistically assign cases to DAs. This method results in less precise matching than would the full six-character postal code. It may result in greater misclassification of hospital records in urban areas, but has little effect in rural areas which are predominately in the low foreign-born concentration tercile.

Conclusion

The results confirm that this area-based methodology can be employed to compare hospitalization rates among areas having greater versus lesser concentrations of foreign-born than Canadian-born populations. An advantage of this approach is its use of existing data, which makes it a cost-effective method for routine surveillance of health care utilization. As well, the measure allows for comparisons between different geographic areas, particularly those with high foreign-born concentrations.

Finally, definitive analysis of health services use by the foreign-born awaits the creation of administrative data with person-level information such as country of birth, year of immigration, income, and educational attainment. The linkage of health care administrative records to other Statistics Canada data holdings such as the Census under the Longitudinal Health and Administrative Data Initiative should address this information gap. ■

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Appendix

Table A
Population and all-cause hospitalizations, by foreign-born concentration tercile, province/region/territory and selected Census Metropolitan Areas, Canada, 2005/2006

	Population 2006				Hospitalizations 2005/2006			
	Total	Tercile 1 (lowest % foreign-born)	Tercile 2 (medium % foreign-born)	Tercile 3 (highest % foreign-born)	Total	Tercile 1 (lowest % foreign-born)	Tercile 2 (medium % foreign-born)	Tercile 3 (highest % foreign-born)
Province/Region/Territory								
Atlantic	2,274,315	2,263,740	10,575	...	220,292	219,352	940	...
Quebec	7,480,310	6,269,040	906,290	304,980	546,010	471,809	56,282	17,919
Ontario	12,077,010	6,814,775	2,918,810	2,343,425	835,330	539,592	175,488	120,250
Manitoba	1,090,955	925,255	156,895	8,805	91,991	81,063	10,369	559
Saskatchewan	917,545	909,095	7,755	695	104,148	103,163	972	13
Alberta	3,219,455	2,540,690	634,035	44,730	247,682	211,111	34,152	2,419
British Columbia	4,009,085	2,273,955	1,100,105	635,025	294,239	191,963	69,910	32,366
Territories	100,510	100,510	...	...	7,154	7,154	...	...
Census Metropolitan Area								
Vancouver	2,095,580	526,240	944,370	624,970	122,791	35,161	55,869	31,761
Calgary	1,075,680	683,245	356,110	36,325	61,286	40,951	18,642	1,693
Toronto	5,093,485	923,815	1,886,145	2,283,525	279,335	55,128	107,344	116,863
Montreal	3,613,520	2,417,560	890,980	304,980	226,116	152,812	55,320	17,984
Halifax	371,350	365,575	5,775	...	21,632	21,354	278	...
Hamilton	692,120	441,635	235,415	15,070	49,380	30,980	17,412	988
Winnipeg	693,665	542,360	142,500	8,805	45,207	35,326	9,331	550

... not applicable
Notes: Excludes pregnancy-related conditions. Foreign-born include those with landed immigrant status (ever) and non-permanent residents.
Source: 2006 Census of Population; 2005/2006 Hospital Morbidity Database.

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Comparison of waist circumference using the World Health Organization and National Institutes of Health protocols

by Jennifer Patry-Parisien, Margot Shields and Shirley Bryan

Abstract

Background
This study compares waist circumference (WC) measured using the World Health Organization (WHO) and National Institutes of Health (NIH) protocols to determine if the results differ significantly, and whether equations can be developed to allow comparison between WC taken at the two different measurement sites.

Data and Methods
Valid WC measurements using the WHO and NIH protocols were obtained for 6,306 respondents aged 3 to 79 from Cycle 2 of the Canadian Health Measures Survey. Linear regression was used to identify factors associated with the difference between the NIH and WHO values. Separate prediction equations by sex were generated using WC_NIH as the outcome and WC_WHO and age as independent variables. Sensitivity and specificity were calculated to examine whether health risk based on the WC_WHO and on WC_NIH predicted measurements agreed with estimates based on WC_NIH actual measured values.

Results
For adults and children, WC_NIH significantly exceeded WC_WHO (1.0 cm for boys, 2.1 cm for girls, 0.8 cm for men and 2.2 cm for women). Predicted NIH values were statistically similar to measured values. Sensitivity (86% to 98%) and specificity (70% to 100%) values for health risk category based on the NIH predicted values were very high, meaning that respondents would be appropriately classified when compared with actual measured values.

Interpretation
The prediction equations proposed in this study can be applied to historical datasets to compare estimates based on WC data measured using the WHO and NIH protocols.

Keywords
Body composition, central obesity, cross-over study, direct measure, sensitivity, specificity

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Waist circumference (WC) is an important independent measure in the assessment of obesity-related health risk.[1] The 2003 Canadian Guidelines for Weight Classification in Adults recommended that WC be measured on all persons with a body mass index (BMI) between 18.5 and 34.9 kg/m^2, using the World Health Organization (WHO) measurement protocol.[1] In 2006, based on recommendations from an expert panel, the Canadian clinical practice guidelines on the management and prevention of obesity in adults and children suggested that practitioners use the National Institutes of Health (NIH) method to measure WC.[2] Two years later, the Canadian Society for Exercise Physiology (CSEP) adopted the NIH method as part of the measurement protocols in the Canadian Physical Activity and Fitness Lifestyle Approach.[3,4]

In March 2007, Statistics Canada launched the Canadian Health Measures Survey (CHMS), which collects directly measured health data on a nationally representative sample of Canadians. Cycle 1 (2007 to 2009) included WC measurements using the WHO protocol.[5] Cycle 2 (2009 to 2011) used both the WHO and NIH protocols in order to conduct a cross-over study that would compare the measurement techniques based on a large, nationally representative sample.

This paper presents the results of that cross-over study. It compares the measurements of WC using the WHO and NIH measurement protocols, assesses the effect of measurement site on health risk classification, and evaluates the feasibility of predicting WC based on the NIH protocol from WC based on the WHO protocol.

Methods

Data source

The data are from the second cycle of the CHMS. The CHMS is an ongoing survey designed to provide comprehensive, direct health measures at the national level.[6] Cycle 2 covers the population aged 3 to 79 living in private households. Residents of Indian Reserves, institutions and some remote regions, and full-time members of the Canadian Forces are excluded. More than 96% of the Canadian population is represented. Ethics approval for the CHMS was obtained from Health Canada's Research Ethics Board.

Data for Cycle 2 were collected at 18 locations across Canada from August 2009 through December 2011. In addition to a detailed questionnaire administered in the respondent's home, the survey involved physical measures (including WC, height and weight) several days later at a mobile examination centre. Participation in the survey was voluntary, and written informed consent was obtained from respondents for participation in the physical measures component. Additional information about the content and sample design can be found in the *CHMS Cycle 2 Data User Guide*.[7]

Of the households selected for the survey, 75.9% agreed to participate, and 90.5% of selected household members completed the household questionnaire. A total of 6,395 respondents (81.7% of those who completed the household questionnaire) completed the mobile examination centre component. The final response rate, after adjusting for the sampling strategy, was 55.5%. This study pertains to 6,306 respondents for whom WC was measured using both the WHO and NIH protocols. Respondents who had a missing value for either or both protocols were excluded (n=89) from the analysis; this included pregnant women, whose WC was not measured.

Waist circumference measurement and classification

CHMS health measures specialists were trained to measure WC using both the NIH and WHO protocols. WC was measured to the nearest 0.1 cm, directly on the landmarked skin with a flexible, inelastic measuring tape with a tension meter attached.[7] For the NIH protocol, the measure is taken at the highest point of the iliac crest.[8] For the WHO protocol, the measure is taken at the mid-point between the highest point of the iliac crest and the last floating rib[5] (Figure 1). The two measurements were taken consecutively near the beginning of the visit to the mobile examination centre. The health measures specialists landmarked the location of the tape, marked it with a washable marker, and took the measure at the end of a normal expiration, on the right side of the back, using the reflection of the left side of the body in a mirror to ensure that the tape was horizontal.

Based on their WC measurements, adults aged 20 or older were classified into three health risk categories according to cut-offs recommended by the WHO,[5] Health Canada,[1] and Obesity Canada.[2] Those cut-offs were also applied to the NIH protocol. The three categories are: low risk (men, WC 93.9 cm or less; women, WC 79.9 cm or less); increased risk (men, WC 94.0 to 101.9 cm; women, WC 80.0 to 87.9 cm); and high risk (men, WC 102.0 cm or more; women, WC 88.0 cm or more). Adolescents aged 12 to 19 were classified into low-, increased, and high-risk WC categories according to the age- and sex-specific cut-offs proposed by Jolliffe et al.[9] These cut-offs were developed using growth curve modeling, and they correspond to the cut-offs at entry into adulthood at age 20.[9] Comparable WC cut-offs are not available for children younger than 12.

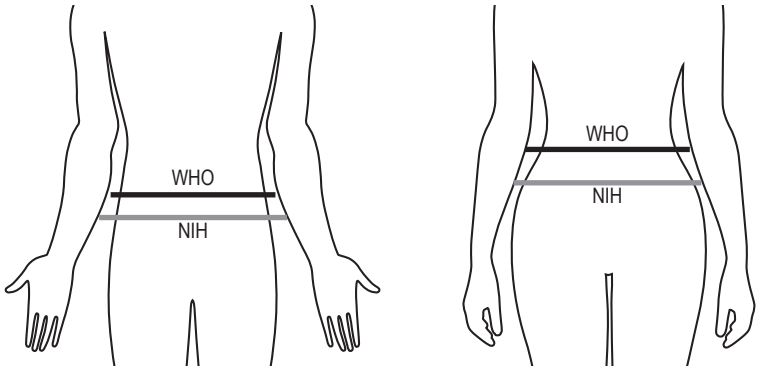
Body mass index measurement and classification

BMI is calculated as weight (kg) divided by height squared (m^2). Height was measured to the nearest 0.1 cm using a ProScale M150 digital stadiometer (Accurate Technology Inc., Fletcher, USA), and weight, to the nearest 0.1 kg with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Canada).

Adults aged 18 or older were classified into six BMI categories: underweight (less than 18.5 kg/m^2), normal weight (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2), obese class I (30 to 34.9 kg/m^2), obese class II (35 to 39.9 kg/m^2), and obese class III (40 kg/m^2 or more).[1,2,5]

Children and teenagers aged 3 to 17 were classified into BMI categories based on growth curves using age- and sex-specific cut-offs of the WHO. The WHO recommends that 5- to 17-year-olds whose BMI is more than two standard deviations (SD) above the mean

Figure 1
Waist circumference measurement sites for men and women based on World Health Organization (WHO) and National Institutes of Health (NIH) protocols



Note: Following the WHO protocol, the measure is taken midway between the highest point of the iliac crest and the bottom of the ribcage. Following the NIH protocol, the measure is taken at the highest point of the iliac crest.

be considered obese, and those whose BMI is between one and two SD above the mean, overweight.[10] Although the WHO recommends a different set of cut-offs for children younger than 5,[11] for this analysis the one- and two-SD cut-offs were used to define overweight and obesity for children aged 3 and 4.

Analytical techniques

The feasibility of predicting WC based on the NIH protocol (WC_NIH) from WC based on the WHO protocol (WC_WHO) was assessed. Scatter plots and linear regression were used to identify factors associated with the difference between the two measurements. The difference was significantly associated with three variables: WC_WHO, BMI, and age (continuous age for children and adult males, and age group for adult females). Because of the high correlation between WC_WHO and BMI, it was not possible to include both in the regression models. WC_WHO was retained because R-squared values were higher for the models using WC_WHO as a predictor of the difference (data not shown).

The sample was then randomly divided into split-sample A and split-sample B, each containing about 50% of respondents. Split-sample A was used to generate prediction equations using WC_NIH as the outcome and WC_WHO and age as independent variables. Separate prediction equations were generated for men and women (ages 20 to 79) and for boys and girls (ages 3 to 19). Outliers (respondents for whom the difference between WC_NIH and WC_WHO was more than three SD from the mean) were excluded when generating the prediction equations; this was the case for 56 (fewer than 2%) of the 3,202 records in split-sample A.

The prediction equations generated from split-sample A were applied to split-sample B. The WC_NIH value calculated from WC_WHO measurement is referred to as "WC_NIH_predicted." To evaluate the success of the prediction equations, the WC_NIH_predicted measurements from split-sample B were compared with the actual measurements. Outliers in split-sample B were included in this evaluation. The estimates were compared by sex for six age groups: 3 to 5, 6 to 11, 12 to 19, 20 to 39, 40 to 59, and 60 to 79. Comparisons were also made by BMI categories, by sex, for adults and for children.

Using split-sample B, the health risk cut-offs were applied to WC_WHO, WC_NIH and WC_NIH_predicted measurements. The percentages of respondents whose WC put them in a high health risk category were compared among the three measurements. Sensitivity and specificity were calculated to examine the extent to which health risk estimates based on WC_WHO and WC_NIH_predicted measurements agreed with health risk estimates based on WC_NIH measurements (WC_NIH was the "gold-standard").

Sensitivity refers to the percentage of true positives—in this case, the percentage of respondents classified at high health risk based on their WC_NIH measurements who were also classified at high health risk based on their WC_WHO and WC_NIH_predicted measurements. Specificity refers to the percentage of true negatives—in this case, the percentage of respondents who were not classified at high health risk based on the WC_NIH measurements who were also not classified at high health risk based on their WC_WHO and on WC_NIH_predicted measurements. Estimates were also calculated and compared for the combined increased/high health risk group.

Prediction equations for detailed age-sex groups were evaluated (data not shown), but the results were similar to those based on the four prediction equations presented in the current study. Crude adjustments were also evaluated, whereby the differences between WHO and NIH measurements were calculated based on split-sample A and then applied to split-sample B. Crude adjustments were made by detailed age-sex groups and by BMI categories (by sex, for adults and for children). The results based on these crude adjustments (data not shown) were not as favourable as those based on the four regression models.

Estimates of percentages, means and regression coefficients were calculated using weighted data. Differences between estimates were tested for statistical significance, which was set at 0.05. Standard errors were estimated with the bootstrap technique; the number of degrees of freedom was specified as 13 to account for the sample design of the data. Weighted estimates were produced to adjust for unequal probabilities of selection and to take advantage of the adjustments made to reduce non-response bias in the CHMS.

Results

Measurements and equations

For men and women aged 20 to 79, the difference between WC_NIH and WC_WHO was negatively associated with WC_WHO; that is, the larger the WC_WHO measurement, the smaller

Table 1
Equations to predict National Institutes of Health waist circumference measures (WC_NIH_predicted) based on waist circumference measured using World Health Organization protocols (WC_WHO), by age group and sex

Age group (years)/ Sex	Equation	R^2
3 to 19		
Boys	WC_NIH_predicted = -0.89911 + 1.01829*(WC_WHO) + 0.05164*(age)	0.99
Girls	WC_NIH_predicted = -0.70299 + 1.01891*(WC_WHO) + 0.12297*(age)	0.99
20 to 79		
Men	WC_NIH_predicted = 3.83072 + 0.98613*(WC_WHO) - 0.03609*(age)	0.99
Women	WC_NIH_predicted = 3.53771 + 0.98479*(WC_WHO) + 0.21949*(x) (where x is set to 1 if age is 20 to 39; otherwise x=0)	0.98

Table 2
Mean waist circumference based on World Health Organization (WHO) and National Institutes of Health (NIH) protocols, by sex and age group, household population aged 3 to 79, Canada, 2009 to 2011

Sex/Age group (years)	Sample size	Measured			NIH predicted			
		NIH	WHO	Difference (NIH minus WHO)	NIH predicted	Difference (NIH predicted minus NIH measured)	95% confidence interval from	95% confidence interval to
	Number	Centimetres						
Boys	**702**	**68.8**	**67.8**	**1.0***	**68.7**	**-0.1**	**-0.3**	**0.0**
3 to 5	151	52.4	52.0	0.4*	52.2	-0.1	-0.4	0.1
6 to 11	277	61.0	60.2	0.8*	60.8	-0.2	-0.5	0.1
12 to 19	274	81.3	79.8	1.5*	81.1	-0.1	-0.4	0.1
Girls	**670**	**66.7**	**64.7**	**2.1***	**66.6**	**-0.2**	**-0.4**	**0.1**
3 to 5	143	51.5	50.8	0.7*	51.5	0.1	-0.2	0.4
6 to 11	274	59.5	58.2	1.3*	59.7	0.2	-0.1	0.5
12 to 19	253	76.1	73.1	3.1*	75.6	-0.5*	-0.9	-0.1
Men	**824**	**95.3**	**94.5**	**0.8***	**95.4**	**0.1**	**-0.2**	**0.4**
20 to 39	270	88.8	87.5	1.3*	89.0	0.2	-0.2	0.6
40 to 59	303	97.1	96.4	0.8*	97.1	-0.1	-0.6	0.5
60 to 79	251	103.2	103.3	-0.1	103.3	0.1	-0.3	0.4
Women	**908**	**89.2**	**87.0**	**2.2***	**89.3**	**0.1**	**-0.3**	**0.4**
20 to 39	355	85.6	82.8	2.8*	85.3	-0.3	-0.9	0.2
40 to 59	284	89.4	87.4	2.1*	89.6	0.2	-0.2	0.5
60 to 79	269	95.2	93.7	1.5*	95.8	0.6	-0.02	1.2

* significantly different from zero ($p < 0.05$)
Note: Estimates are generated from sub-sample B.
Source: 2009 to 2011 Canadian Health Measures Survey.

Table 3
Difference between waist circumference measured according to National Institutes of Health (NIH) and World Health Organization (WHO) protocols, by sex and age group, household population aged 3 to 79, Canada, 2009 to 2011

Sex/Age group (years)	Difference									
	NIH measured versus WHO measured					NIH predicted versus NIH measured				
	≤1 cm	≤2 cm	≤3 cm	≤4 cm	> 4 cm	≤1 cm	≤2 cm	≤3 cm	≤4 cm	>4 cm
	%					%				
Boys	**53**	**81**	**92**	**98**	**2**	**69**	**93**	**97**	**99**	**1**
3 to 5	71	96	100	100	0	74	96	100	100	0
6 to 11	65	88	96	97	3	72	94	96	98	2
12 to 19	36	69	87	98	2	64	91	97	98	2
Girls	**34**	**58**	**75**	**85**	**15**	**53**	**80**	**92**	**95**	**5**
3 to 5	67	87	97	99	1	66	95	99	100	0
6 to 11	47	75	90	96	4	58	85	98	100	0
12 to 19	16	38	57	73	27	45	73	85	91	9
Men	**45**	**75**	**91**	**96**	**4**	**50**	**86**	**94**	**97**	**3**
20 to 39	41	73	91	98	2	53	87	97	99	1
40 to 59	47	76	93	96	4	47	88	95	97	3
60 to 79	49	78	90	95	5	53	79	90	95	5
Women	**25**	**48**	**67**	**81**	**19**	**38**	**71**	**89**	**96**	**4**
20 to 39	15	36	55	69	31	34	63	87	97	3
40 to 59	27	52	75	90	10	46	82	93	97	3
60 to 79	40	59	73	83	17	31	62	82	90	10

Note: Estimates are generated from sub-sample B.
Source: 2009 to 2011 Canadian Health Measures Survey.

the difference (Appendix Table A). For men, the association with age was negative. For women, the association with age was not linear, but when age groups were included in the regression model, a positive association emerged for women aged 20 to 39.

For boys and girls aged 3 to 19, a positive relationship was observed between the difference and both WC_WHO and age. That is, higher values of WC_WHO and age were associated with larger differences.

The prediction equations derived from split-sample A to calculate WC_NIH_predicted based on WC_WHO and age are presented in Table 1.

Measured and predicted waist circumferences

Regardless of age and sex, mean values of WC_NIH significantly exceeded those of WC_WHO: 1.0 cm for boys, 2.1 cm for girls; 0.8 cm for men, and 2.2 cm for women (Table 2). The differences were greatest for girls aged 12 to 19 (3.1 cm) and women aged 20 to 39 (2.8 cm).

Overall, the measured and predicted NIH values were statistically similar (mean differences range from -0.2 cm to 0.1 cm) (Table 2). For the detailed age-sex groups, the only significant difference was for girls aged 12 to 19 (-0.5 cm).

At ages 3 to 19, WC_NIH_predicted was within 1 cm of WC_NIH measured for 69% of boys and 53% of girls (Table 3). A difference of more than 2 cm was observed for 7% of boys and 20% of girls overall, and 27% of girls aged 12 to 19.

Half of men had a predicted NIH value within 1 cm of the measured value; a difference of more than 2 cm was observed in 14% of cases. For women, the predicted value was within 1 cm of the measured value in 38% of cases; in 29% of cases, the difference was more than 2 cm.

For all age-sex groups, the predicted value was within 4 cm of the measured value in at least 90% of cases.

Body mass index

Among children and adolescents, differences between measured WC_

WHO and WC_NIH were greater for those classified as obese: a mean difference of 1.6 cm for boys and 2.5 cm for girls (Table 4). Among adults, differences were greater for those in the normal weight range: 1.3 cm for men and 2.7 cm for women.

The only significant difference between the measured and predicted NIH values was for obese boys (-0.4 cm). Although the measured and predicted NIH means were fairly close for women in obese categories II and III, a difference of more than 2 cm was observed in 50% of cases (Table 5).

Health risk

For men and boys, the percentages whose waist circumference put them in a high health risk category were similar whether based on WHO, NIH or NIH-predicted measures (Table 6). For men, the prevalence of increased/high health risk was slightly elevated when WC was based on NIH rather than on WHO, and the prevalence of increased/high health risk based on the predicted NIH values was similar to the estimate based on the measured NIH values.

For women and girls, the percentages whose waist circumference put them in a high (or increased/high) health risk category were significantly greater based on NIH rather than WHO measures, while estimates based on the predicted NIH values were similar to those based on NIH measured values.

Sensitivity and specificity

Sensitivity and specificity were very high when based on NIH predicted values, meaning that in almost all cases, respondents would be classified in the appropriate health risk category—that is, the same category in which they would be placed based on measured values (Table 7). Sensitivity and specificity were 90% or more, with two exceptions: specificity was somewhat low (70%) for increased/high risk for women aged 60 to 79, and sensitivity for girls aged 12 to 19 was 86% for high risk and 89% for increased/high risk. However, these sensitivity values were an improvement over those based on WHO.

Table 4
Mean waist circumference based on World Health Organization (WHO) and National Institutes of Health (NIH) protocols, by age group, sex and body mass index (BMI) category, household population aged 3 to 79, Canada, 2009 to 2011

Age group/ Sex/ BMI category	Sample size	Measured			NIH predicted			
		NIH	WHO	Difference (NIH minus WHO)	NIH predicted	Difference (NIH predicted minus NIH measured)	95% confidence interval	
							from	to
	Number	Centimetres						
Ages 3 to 19								
Boys								
Normal weight	438	63.4	62.5	0.9*	63.3	-0.1	-0.3	0.1
Overweight	139	69.7	68.7	1.0*	69.6	-0.1	-0.5	0.2
Obese	111	87.0	85.4	1.6*	86.7	-0.4*	-0.7	-0.01
Girls								
Normal weight	467	62.5	60.5	2.0*	62.3	-0.1	-0.4	0.1
Overweight	137	71.9	69.6	2.3*	71.5	-0.4	-1.0	0.2
Obese	58	90.2	87.7	2.5*	90.2	0.1	-1.0	1.1
Ages 20 to 79								
Men								
Normal weight	219	83.0	81.7	1.3*	83.0	0.0	-0.5	0.5
Overweight	360	95.9	95.1	0.8*	95.9	0.1	-0.4	0.5
Obese class I	174	107.6	107.3	0.3	107.8	0.2	-0.3	0.7
Obese class II/III	67	125.1	125.1	0.0	125.3	0.3	-0.4	0.9
Women								
Normal weight	365	78.2	75.5	2.7*	78.0	-0.2	-0.6	0.2
Overweight	270	91.6	89.6	2.0*	91.8	0.2	-0.3	0.7
Obese class I	156	101.9	100.2	1.7*	102.2	0.3	-0.2	0.9
Obese class II/III	97	117.4	115.9	1.5*	117.8	0.4	-0.7	1.4

* significantly different from zero ($p < 0.05$)
Notes: Estimates are generated from sub-sample B. Estimates for underweight are not included because of small sample sizes.
Source: 2009 to 2011 Canadian Health Measures Survey.

Discussion

In the present study, WC for Canadian adults and children was significantly greater when measured using the NIH protocol than the WHO protocol. The difference was greatest among girls and young women. These findings add to the limited information about WC measurements taken at different sites.[12,13] In a study based on 111 healthy volunteers aged 7 to 83, Wang et al.[12] compared measurements at four sites—immediately below the lowest rib, at the narrowest waist, midway between the lowest rib and iliac crest (WHO), and immediately above the iliac crest (NIH). In that study, males' mean WC at the narrowest waist was significantly lower than at the other three sites. For females, mean WC at each site differed significantly from means at the others, and WC measurements using the NIH protocol significantly exceeded those using the WHO protocol (1.82 cm).[12]

Mason et al.[13] conducted a more recent study (2009) of 542 healthy volunteers aged 20 to 67 to assess whether WC differed across four commonly used measurement sites. They noted no significant differences between sites for men. For women, the mean for each site differed significantly from the means for the others, except for the means at the sites used for the NIH and WHO protocols, which did not differ.[13]

In the present study, the differences that emerged between the NIH and WHO protocols may be related to the sample size or sample characteristics (the Mason sample consisted of healthy adult volunteers, while the CHMS

Table 5
Difference between waist circumference measured according to National Institutes of Health (NIH) and World Health Organization (WHO) protocols, by age group, sex and body mass index (BMI) category, household population aged 3 to 79, Canada, 2009 to 2011

Age group/ Sex/ BMI category	Difference									
	NIH measured versus WHO measured					NIH predicted versus NIH measured				
	≤1 cm	≤2 cm	≤3 cm	≤4 cm	> 4 cm	≤1 cm	≤2 cm	≤3 cm	≤4 cm	>4 cm
	%					%				
Ages 3 to 19										
Boys										
Normal weight	59	85	96	98	2	70	94	98	99	1
Overweight	50	85	91	98	2	75	94	98	100	0
Obese	33	61	80	95	5	54	87	92	96	4
Girls										
Normal weight	35	61	76	87	13	56	82	94	96	4
Overweight	30	51	74	81	19	51	75	85	94	6
Obese	38	51	62	77	23	27	79	93	93	7
Ages 20 to 79										
Men										
Normal weight	39	71	92	98	2	49	88	97	99	1
Overweight	47	75	91	96	4	51	86	94	95	5
Obese class I	53	83	93	95	5	56	84	94	99	1
Obese class II/III	42	81	86	95	5	36	80	87	96	4
Women										
Normal weight	18	40	61	76	24	37	72	90	97	3
Overweight	31	55	71	89	11	41	77	92	97	3
Obese class I	40	55	79	88	12	42	68	87	91	9
Obese class II/III	25	47	64	72	28	28	50	76	92	8

Notes: Estimates are generated from sub-sample B. Estimates for underweight are not included because of small sample sizes.
Source: 2009 to 2011 Canadian Health Measures Survey.

Table 6
Percentage with high and increased/high health risk based on waist circumference according to World Health Organization (WHO) and National Institutes of Health (NIH) protocols, by sex and age group, household population aged 12 to 79, Canada, 2009 to 2011

Sex/Age group (years)	High health risk			Increased/High health risk		
	WHO measured	NIH measured	NIH predicted	WHO measured	NIH measured	NIH predicted
	%			%		
Boys aged 12 to 19	**13[E]**	**14[E]**	**14[E]**	**20[E]**	**20[E]**	**20[E]**
Girls aged 12 to 19	**15*[E]**	**22[E]**	**20[E]**	**31***	**41**	**37**
Men	**26**	**29**	**28**	**47***	**50**	**48**
20 to 39	12[E]	16[E]	15[E]	24[E]	27[E]	26[E]
40 to 59	26[E]	30	27[E]	54	56	55
60 to 79	51	50	51	75	76	76
Women	**41***	**46**	**46**	**60***	**70**	**67**
20 to 39	28*	33	30	45*	54	52
40 to 59	42*	47	50	65*	77	70
60 to 79	62*	69	67	79*	85	88

* significantly different from NIH measured (p<0.05)
[E] use with caution
Note: Estimates are generated from sub-sample B.
Source: 2009 to 2011 Canadian Health Measures Survey.

sample is representative of the Canadian population aged 3 to 79).

In a comprehensive review, Ross et al.[14] suggested that the protocol used to measure WC does not substantially influence the association between WC and all-cause mortality, cardiovascular disease mortality, and cardiovascular disease and diabetes morbidity. In the present study, the classification of men and boys into the high health risk category was similar regardless of whether WC was measured using the WHO or NIH protocol. However, the prevalence of high health risk for women and girls, and the prevalence of combined increased/high health risk among men were significantly greater when measures were based on the NIH protocols than on the WHO protocols. Similarly, Mason et al.[13] reported that the prevalence of abdominal obesity (more than 88 cm for women; more than 102 cm for men) depended on the WC measurement protocol used. When comparing the WHO and NIH protocols, they noted no difference in the prevalence of abdominal obesity for men (32.7% versus 31.8%), but for women, the prevalence was higher based on the NIH protocol (47.0%) than on the WHO protocol (41.1%).[13] Willis et al.[15] used different WC measurement protocols, but they also noted that classification of health risk depends on which protocol is used. When WC was measured at the umbilicus rather than the minimal waist, 54% more men and 68% more women met the National Cholesterol Education Program criteria for abdominal obesity.[15]

To assess the accuracy of the prediction equations proposed in this study, the difference between the measured NIH value and the predicted NIH value was calculated on a portion of the sample. For the majority of cases, the equations yield statistically similar WC values. And although the results show a difference greater than 2 cm for 50% of women in obese class II and III, this would not be a meaningful difference for health-risk assessment at these levels of BMI.

Table 7
Sensitivity and specificity for high and increased/high health risk according to waist circumference, based on World Health Organization (WHO) and predicted National Institutes of Health (NIH) protocols, by sex and age group, household population aged 12 to 79, Canada, 2009 to 2011

	NIH predicted				WHO measured			
	Sensitivity (% true positives)		Specificity (% true negatives)		Sensitivity (% true positives)		Specificity (% true negatives)	
Sex/Age group (years)	High risk	Increased /High risk	High risk	Increased /High risk	High risk	Increased /High risk	High risk	Increased /High risk
Boys aged 12 to 19	**98**	**98**	**100**	**100**	**94**	**97**	**100**	**100**
Girls aged 12 to 19	**86**	**89**	**99**	**99**	**69**	**77**	**100**	**100**
Men	**91**	**95**	**98**	**98**	**86**	**94**	**99**	**98**
20 to 39	92	95	100	99	73	88	100	99
40 to 59	86	95	98	98	84	94	99	98
60 to 79	96	96	94	89	96	96	94	90
Women	**95**	**93**	**95**	**93**	**88**	**85**	**100**	**99**
20 to 39	88	93	99	96	84	83	100	100
40 to 59	98	90	91	95	89	84	100	99
60 to 79	95	98	95	70	90	92	100	96

Note: Estimates are generated from sub-sample B using NIH measured as the standard.
Source: 2009 to 2011 Canadian Health Measures Survey.

Sensitivity and specificity were calculated to examine the extent to which health risk estimates based on WC_WHO and WC_NIH_predicted measurements agreed with those based on WC_NIH measurements. The sensitivity and specificity values were generally very high for WC_NIH_ predicted values, which means that respondents would be correctly classified into the appropriate health risk category based on the predicted NIH values. In a few cases, the absolute differences between the predicted and measured NIH values were large, but from a clinical perspective, the predicted values result in the correct health risk assessment. These findings suggest that the equations generated from the CHMS dataset can be applied to historical WHO data so that WHO and NIH waist circumference data can be compared. These equations can be applied to a broader age range (including 3- to 19-year-olds) than those proposed by Mason et al.[13]

A strength of this analysis is the large sample from the general population, ranging in age from 3 to 79, which made it possible to examine differences in WC by age, sex and BMI.

The differences between the measurement protocols that emerged are not the result of inter- or intra-tester variability. CHMS staff underwent biannual training with a measurement expert, were regularly observed as they measured the respondents, and were monitored by assessments of the technical error of measurement (TEM)[16] once a year. The TEM compares measurements made by CHMS staff with measurements of a gold standard. To ensure high data quality, a low TEM threshold (1.5%) was set, based on the literature.[16] On average, the relative TEM result was 1.42% for measurements taken using the WHO protocol, and ranged from 1.79% to 3.06% for measurements taken using the NIH protocol, which are very close to the target.

Another strength of the study is that measurements using the two protocols were taken one after another on the same day. Consequently, factors such as food and beverage consumption, time of day and menstrual cycle did not affect differences between them.

What is already known on this subject?

- Abdominal obesity is associated with increased all-cause and cardiovascular mortality, and cardiovascular disease and diabetes morbidity.
- Waist circumference provides information beyond body mass index in the assessment of obesity-related health risk in clinical settings.
- Waist circumference measurements differ, depending on the measurement protocol used.

What does this study add?

- This study examines the difference between waist circumference measured using the World Health Organization (WHO) and National Institutes of Health (NIH) protocols on a large, representative sample of Canadians aged 3 to 79.
- Waist circumference measures based on the WHO and NIH protocols differ significantly.
- The prediction equations in this study can be used to compare estimates based on the WHO and NIH protocols on a wide range of age groups.

Conclusion

The CSEP and the Canadian clinical practice guidelines have adopted the NIH protocol as the standard method for WC measurement in Canada. The prediction equations proposed in this study can be applied to historical Canadian datasets in which the WHO protocol was used. This will allow researchers to assess WC trends over time. ■

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Appendix

Table A
Regression coefficients for difference between waist circumference based on National Institutes of Health and World Health Organization (WHO) protocols, by age group and sex, household population aged 3 to 79, Canada, 2009 to 2011

	Ages 3 to 19		Ages 20 to 79	
	Boys	Girls	Men	Women
	Regression coefficient (B)			
Intercept	-1.20268*	-1.02162*	4.01038*	3.70067*
WHO waist circumference (cm)	0.02574*	0.02349*	-0.01952*	-0.01852*
Age continuous	0.03825*	0.12454*	-0.02881*	
Age group				
20 to 39	...	...	...	0.48826*
40 to 79†	...	...	...	...
Adjusted R squared	0.18	0.25	0.13	0.04

† reference group
* significantly different from zero ($p < 0.05$)
... not applicable
Source: 2009 to 2011 Canadian Health Measures Survey.