Incidence of lower limb amputation in Canada

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ABSTRACT

OBJECTIVES: To determine the Canadian age-adjusted incidence rates of lower limb amputation (LLA) by province, sex, level, and cause of amputation.

METHODS: Data on all hospital discharges associated with LLA from April 1, 2006, to March 31, 2012, were obtained from the Canadian Institute for Health Information's Discharge Abstract Database. National and provincial age-adjusted rates were calculated per 100 000 individuals by sex, level, and cause of LLA using the direct method of standardization. The relative risk of LLA in people with diabetes was calculated.

RESULTS: There were a total of 44 430 LLAs performed in Canada over the study years. The number of LLAs increased from 7331 in 2006 to 7708 in 2011. Mean (SD) age was 65.7 (16.6) years, and 68.8% were males. Sixty-five percent of the LLA cases were due to diabetes. The average age-adjusted rate of LLA in Canada was 22.9 per 100 000 individuals. The age-adjusted rates declined over the study years. The relative risk of diabetes-related LLAs was 28.9.

CONCLUSION: This study provided the first Canadian national and provincial age-adjusted incidence rates of LLA and a baseline for monitoring and evaluation in the future. Understanding the incidence of LLA is essential to managing preventive and rehabilitation services for this population. Although the age-adjusted LLA incidence rates have decreased, the number of new LLAs has increased. The increase in the number of LLAs has important implications for social and health care costs.

KEY WORDS: Incidence; epidemiology; amputation; diabetes; Canada

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Can J Public Health 2017;108(4):e374–e380
doi: 10.17269/CJPH.108.6093

Lower limb amputation (LLA) is a disabling and costly condition.¹ Cost estimates are not available for Canada; however, in the United States the costs associated with acute and post-acute care for LLAs exceeds \$4 billion annually.¹ There are multiple causes associated with LLA, including complications associated with diabetes or other vascular diseases, trauma, congenital limb deformities, or bone cancer. The main reason for LLA in Western countries is attributed to the complications associated with diabetes.²

The incidence of LLA varies widely throughout the world,³ ranging from 8.8 per 100 000 in the Netherlands in 2004⁴ to 92.5 per 100 000 individuals in Ireland in 2009.⁵ Unlike earlier studies that have shown an increase in the incidence of LLA in Western countries,⁶ the most recent studies have reported a decline or no change in the rates.^{7–9} The LLA incidence data are unknown for Canada. As a result, incidence rates from other countries, particularly the United States, are commonly used to support health care planning and research initiatives. Lawee and Csima¹⁰ and Dawes et al.⁸ have reported the only Canadian studies of LLA incidence to date. Using the US diabetes population statistics, Lawee and Csima found the annual incidence rate of LLA among individuals living with diabetes in Ontario, from 1987 to 1988, to be 440 per 100 000 individuals.¹⁰ Dawes et al. reported the incidence of LLAs in Quebec to be 15 992 LLAs from 1996 to 2004.⁸

While providing some insight, the above two studies have important limitations that justify the need for our current study. First, they provide only regional data without any indication of

national rates. Data at the national level are critical because health and health-related data, such as diabetes rates, vary across provinces, and this variability could affect incidence rates.^{11,12} Additionally, understanding the incidence rates from both national and provincial perspectives is essential for developing national/provincial strategies to inform health policy and manage preventive and rehabilitation services. The second limitation, for the Ontario study specifically, is that the data are outdated and provided only for diabetes-related LLAs at a single point in time.¹⁰ Reporting on variations in the rates over a period of time (e.g., at least a few years) rather than a single time point, and also on all causes of LLA rather than just diabetes-related LLAs, would be valuable because it would provide information about changes in

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Acknowledgements: We acknowledge the Canadian Institute for Health Information for providing the data for this study and our staff at GF Strong Rehabilitation Research Program for helping with the study.

Funding: This study was funded by Amputee Coalition of Canada and the University of Alberta's Faculty of Medicine & Dentistry-Franklin Fund. Vanier Canada graduate scholarships provided salary for Bitu Imam. Michael Smith Foundation provided salary for Janice Eng.

Conflict of Interest: None to declare.

the incidence and etiology of LLA. Third, the reported incidence is age-unadjusted. Age-unadjusted rates are not ideal because they do not allow comparison with the rates from other countries or rates across different years that have different age compositions.^{13,14} Recently, Kayssi et al.¹⁵ reported on LLAs in Canada from 2006 to 2009. According to this study, 5342 individuals underwent LLA for vascular reasons, 81% of those being related to complications associated with diabetes. Although this study provided important information about LLA in Canada, data pertaining to Quebec, trauma, and pediatric cases were excluded. In addition, the overall age-adjusted incidence rate of LLA, as well as the incidence rates by sex, province, level, and cause of LLA, were not reported.

Therefore, the primary objective of this study was to determine the age-adjusted incidence rate of LLA in Canada per 100 000 individuals. The secondary objectives were to provide the age-adjusted incidence rates of LLA by 10 Canadian provinces, sex, level of LLA, and cause of LLA per 100 000 individuals. We also looked at the most recent six-year temporal changes in the age-adjusted incidence rates. Since diabetes is expected to be the main reason for LLA in Canada, the tertiary objective was to assess the relative risk of LLA among individuals with diabetes compared with individuals without diabetes. Determining the value of relative risk will provide useful insights into the extent to which the risk of the incidence of LLA is increased among people with diabetes as compared to those without.

METHODS

Design and population

Data on all acute inpatient cases for individuals who had been discharged from the hospital with the recorded procedure codes for LLAs (from hip and pelvis to toes), from April 1, 2006, to March 31, 2012, were obtained from the Discharge Abstract Database (DAD) of the Canadian Institute for Health Information (CIHI). The most recent data available at the time of the data request were related to the year 2012. As CIHI releases data according to fiscal year, the most recent data obtained were for March 31, 2012. The start date was selected because the new coding systems, the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10-CA)¹⁶ and the Canadian Classification of Health Interventions (CCI),¹⁷ were implemented by 2006 in all Canadian provinces.

We extracted the procedure codes from CCI and used them to identify the LLA cases from the DAD. Similarly, we extracted the diagnosis codes from the ICD-10-CA and used these to determine the diagnoses (e.g., diabetes) for each patient.

The final data obtained from CIHI contained six statistical analysis system files, each relating to a fiscal year. Each row corresponded to an LLA hospitalization consisting of one or more LLA procedures on a single individual. Each hospitalization contained a unique, meaningless patient identification code to allow tracking if the individual had single or multiple LLAs over the study years. Variables including sex, age, province, year, level of amputation, and diagnoses were also obtained for each LLA case.

The CCI procedure codes recorded for each hospitalization indicated the level of the LLA(s). The CCI data were decoded and aggregated by a statistician to accurately count the number of different levels of LLA. Seven categories were defined on the basis

of the CCI codes: hip and pelvis, transfemoral, knee disarticulation, transtibial, ankle, foot, and toes.²

The following rules were used to count the number of LLAs. When more than one LLA procedure was found in a single hospital visit for an individual on one limb, we only counted the highest level. For example, if both ankle and transtibial amputations were done on one limb in one visit, we only counted the transtibial amputation. If there was more than one LLA on both limbs (both left and right) in a single hospitalization, we counted the highest level of LLA for each limb. Last, if there was more than one LLA in more than one visit for an individual we counted all of these LLAs separately. For example, if an individual had both ankle and transtibial amputations in two separate visits, both LLAs were counted separately.

The ICD-10-CA diagnosis code(s) recorded for each hospitalization provided insights into the most probable cause of LLA. The ICD-10-CA data were decoded and aggregated by the statistician to allow categorizing of the causes of LLAs. Consistent with other similar studies,⁸ five categories were defined using the ICD-10-CA codes: diabetes, other vascular diseases/infections, trauma, cancer, and congenital disorders. For each hospitalization, the first recorded diagnosis associated with the visit (e.g., codes for trauma) was selected as the most probable cause of amputation, with an exception for the other vascular diseases/infections category. If the first diagnosis was vascular diseases/infections other than diabetes, we looked at the other diagnoses. The rationale behind this was that vascular diseases and infections in these individuals were likely to have been preceded by complications/infections associated with diabetes or trauma causes. If a code(s) for diabetes but no trauma was found, the cause was flagged as diabetes. If a code(s) for trauma but no diabetes were found, the cause was noted as trauma. If neither diabetes nor trauma codes were found, the cause was flagged as other vascular diseases/infections. Finally, if both diabetes and trauma were found, we reviewed the case thoroughly to decide what the likely cause has been.

Ethics approval was obtained from the Clinical Research Ethics Board of the University of British Columbia, Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal, and Commission to Access Information in Quebec in Canada.

Data analyses

Demographic and Descriptive Data

The characteristics of LLAs in Canada and across the provinces were described using means and standard deviations (SD), and frequency (%).

Primary Objective

Age-specific national and provincial incidence rates were calculated for three age groups (0–49, 50–74, and 75+ years old), because generally the LLA incidence is expected to be different among these groups.² To calculate the age-specific incidence rates, the number of new cases of LLA in a specific age group was divided by the size of the population at risk for each specific age group. The size of the population at risk was calculated by subtracting the number of new LLAs from the general population. National and provincial population sizes from 2006 to 2011 were taken from the 2011 Canadian Census.¹⁸

The direct method of age-adjustment was used to adjust the amount that each age group contributed to the overall rate in each year, so that the overall rates were based on the same age structure and allowed for comparison over the study years or across provinces.^{12,13} The direct method of adjustment was determined by first multiplying the age-specific rates by age-specific weights in a standard population.¹⁹ Age-specific weights were taken from the weights for the final post-censal Canadian population in 2011. The weighted rates were then summed across the age groups to give the total age-adjusted rate. Age-adjusted rates were calculated for each year separately per 100 000 individuals and were then averaged to derive the overall rate in Canada.

Secondary Objective

The direct method of standardization was used to determine age-adjusted rates by province, sex, level of LLA, and cause of LLA. The rates were calculated per 100 000 individuals. We presented the yearly rates as well as the overall averaged rate.

Tertiary Objective

The relative risk of diabetes-related LLAs was calculated by dividing the age-adjusted incidence rate of LLA among people with diabetes over the age-adjusted incidence rate of LLA among people without diabetes. The population of individuals with and without diabetes was obtained from Statistics Canada.¹¹

Since this study reported data on the entire population and not samples of the population, confidence intervals or *p* values were not used.²⁰

RESULTS

Demographic and Descriptive Data

From April 1, 2006, to March 31, 2012, there were a total of 44 430 LLAs performed in Canada. The number of LLAs increased from 7331 in 2006 to 7708 in 2011. Mean (SD) age at amputation was 65.7 (16.6) years old, and 30 560 (68.8%) were males. More than half of the LLAs occurred in the 50–74 age category (*n* = 24 400, 54.9%). The number of transtibial amputations was the highest (*n* = 13 708, 30.9%) compared with the other LLA levels. The main cause of amputation was diabetes (*n* = 29 086, 65.4%) (Table 1).

Primary Objective

The average age-adjusted rate of LLA in Canada from April 1, 2006, to March 31, 2012, was 22.9 per 100 000 (Table 2).

Secondary Objective

Among all provinces, Quebec and British Columbia had the lowest age-adjusted LLA incidence rates (average rate from 2006 to 2011 = 19.6 and 20.1 per 100 000 individuals respectively), while Newfoundland and Labrador had the highest rate (average rate from 2006 to 2011 = 37.9 per 100 000 individuals) (Table 2). The average age-adjusted incidence rate over the study years among males was 34.0 per 100 000, whereas in females it was 13.2 per 100 000 (Figure 1). As shown in Figure 2, of all levels of amputations, transtibial amputations had the highest rate (7.1 per 100 000), followed by foot amputations (6.3 per 100 000). The

Table 1. Characteristics of LLA in Canada and 10 provinces for fiscal years 2006–2011

	2006	2007	2008	2009	2010	2011	Total
Total amputations, <i>n</i>	7331	7190	7466	7367	7368	7708	44 430
Amputations (0–49 years old), <i>n</i> (%)	1068 (14.6)	976 (13.6)	1078 (14.4)	1120 (15.2)	1034 (14.0)	981 (12.7)	6257 (14.1)
Amputations (50–74 years old), <i>n</i> (%)	4002 (54.6)	3933 (54.7)	3982 (53.3)	4045 (54.9)	4053 (55.0)	4385 (56.9)	24 400 (54.9)
Amputations (75+ years old), <i>n</i> (%)	2261 (30.8)	2281 (31.7)	2406 (32.2)	2202 (29.9)	2281 (31.0)	2342 (30.4)	13 773 (31.0)
Mean (SD) age	65.1 (16.9)	65.7 (16.2)	65.7 (16.7)	65.2 (16.7)	65.7 (16.9)	65.8 (16.1)	65.7 (16.6)
Sex (males), <i>n</i> (%)	5007 (68.3)	4903 (68.2)	5032 (67.4)	5201 (70.6)	5106 (69.3)	5311 (68.9)	30 560 (68.8)
Hip and pelvis amputations, <i>n</i> (%)	47 (0.6)	42 (0.6)	56 (0.8)	47 (0.6)	61 (0.8)	56 (0.7)	309 (0.7)
Transfemoral amputations, <i>n</i> (%)	1786 (24.4)	1787 (24.9)	1821 (24.4)	1735 (23.6)	1743 (23.7)	1731 (22.5)	10 603 (23.9)
Knee disarticulation amputations, <i>n</i> (%)	74 (1.0)	77 (1.1)	85 (1.1)	95 (1.3)	86 (1.2)	49 (0.6)	466 (1.0)
Transtibial amputations, <i>n</i> (%)	2290 (31.2)	2226 (31.0)	2221 (29.7)	2290 (31.1)	2243 (30.4)	2438 (31.6)	13 708 (30.9)
Ankle amputations, <i>n</i> (%)	46 (0.6)	40 (0.6)	40 (0.5)	44 (0.6)	40 (0.5)	31 (0.4)	241 (0.5)
Foot amputations, <i>n</i> (%)	2098 (28.6)	2039 (28.4)	2216 (29.7)	1898 (25.8)	1887 (25.6)	2084 (27.0)	12 222 (27.5)
Toe amputations, <i>n</i> (%)	985 (13.4)	975 (13.6)	1024 (13.7)	1257 (17.1)	1307 (17.7)	1318 (17.1)	6866 (15.4)
Diabetes amputations, <i>n</i> (%)	4620 (63.0)	4637 (64.5)	4843 (64.9)	4874 (66.2)	4883 (66.3)	5229 (67.8)	29 086 (65.4)
Other vascular diseases/infections amputations, <i>n</i> (%)	2012 (27.4)	1865 (25.9)	1931 (25.9)	1844 (25.0)	1846 (25.1)	1881 (24.4)	11 379 (25.6)
Trauma amputations, <i>n</i> (%)	455 (6.2)	470 (6.5)	476 (6.4)	457 (6.2)	416 (5.6)	405 (5.3)	2679 (6.0)
Cancer amputations, <i>n</i> (%)	152 (2.1)	143 (2.0)	136 (1.8)	105 (1.4)	140 (1.9)	128 (1.7)	804 (1.8)
Congenital amputations, <i>n</i> (%)	52 (0.7)	36 (0.5)	33 (0.4)	46 (0.6)	55 (0.7)	48 (0.6)	270 (0.6)
AB amputations, <i>n</i> (%)	714 (9.8)	640 (8.9)	740 (9.9)	748 (10.2)	752 (10.2)	879 (11.4)	4473 (10.1)
BC amputations, <i>n</i> (%)	837 (11.4)	873 (12.2)	867 (11.6)	866 (11.8)	903 (12.3)	970 (12.6)	5316 (12.0)
MB amputations, <i>n</i> (%)	394 (5.4)	380 (5.3)	420 (5.6)	423 (5.8)	421 (5.7)	405 (5.3)	2443 (5.5)
NB amputations, <i>n</i> (%)	247 (3.4)	205 (2.9)	209 (2.8)	217 (3.0)	182 (2.5)	174 (2.3)	1234 (2.8)
NL amputations, <i>n</i> (%)	214 (2.9)	203 (2.8)	197 (2.6)	177 (2.4)	219 (3.0)	187 (2.4)	1197 (2.7)
NS amputations, <i>n</i> (%)	308 (4.2)	264 (3.7)	307 (4.1)	256 (3.5)	264 (3.6)	326 (4.2)	1725 (3.9)
ON amputations, <i>n</i> (%)	2766 (37.8)	2761 (38.5)	2838 (38.1)	2748 (37.4)	2773 (37.7)	2839 (36.9)	16 724 (37.7)
PE amputations, <i>n</i> (%)	62 (0.8)	38 (0.5)	34 (0.5)	34 (0.5)	27 (0.4)	36 (0.5)	231 (0.5)
QC amputations, <i>n</i> (%)	1475 (20.1)	1522 (21.2)	1586 (21.3)	1598 (21.7)	1544 (21.0)	1587 (20.6)	9312 (21.0)
SK amputations, <i>n</i> (%)	305 (4.2)	293 (4.1)	251 (3.4)	283 (3.9)	275 (3.7)	300 (3.9)	1707 (3.8)

Note: LLA = lower limb amputation; AB = Alberta; BC = British Columbia; MB = Manitoba; NB = New Brunswick; NL = Newfoundland and Labrador; NS = Nova Scotia; ON = Ontario; PE = Prince Edward Island; QC = Quebec; SK = Saskatchewan.

Table 2. National age-specific and age-adjusted LLA incidence rates as well as provincial age-adjusted incidence rates for fiscal years 2006–2011 (per 100 000)

	2006	2007	2008	2009	2010	2011	Overall
<i>Canada</i>							
Age-specific rates							
0–49 years old	4.8	4.4	4.9	5.0	4.6	4.4	4.7
50–74 years old	47.9	45.6	44.8	44.0	42.7	44.8	45.0
75+ years old	111.5	109.7	113.1	101.5	102.9	103.5	107.0
Age-adjusted rates	24.1	23.1	23.4	22.5	22.0	22.4	22.9
<i>Provincial age-adjusted rates</i>							
AB	25.4	22.1	24.6	24.0	23.7	26.7	24.4
BC	20.2	20.5	19.9	19.4	19.8	20.7	20.1
MB	35.6	33.9	36.9	36.4	35.7	33.9	35.4
NB	32.9	26.7	26.8	27.5	22.7	21.1	26.3
NL	42.8	40.1	38.1	32.9	40.0	33.4	37.9
NS	32.6	27.4	31.4	25.8	26.1	31.8	29.2
ON	23.9	23.3	23.3	22.1	21.7	21.7	22.7
PE	44.8	27.1	23.6	23.2	17.9	23.3	26.7
QC	19.9	20.0	20.3	19.9	18.8	18.9	19.6
SK	31.7	30.2	25.3	27.6	26.4	28.5	28.3

Note: LLA = lower limb amputation; AB = Alberta; BC = British Columbia; MB = Manitoba; NB = New Brunswick; NL = Newfoundland and Labrador; NS = Nova Scotia; ON = Ontario; PE = Prince Edward Island; QC = Quebec; SK = Saskatchewan.

Figure 1. Age-adjusted LLA incidence rates in Canada by sex, per 100 000 individuals. Age-standardized final post-censal Canadian population in 2011, direct method **Figure 2.** Age-adjusted LLA incidence rates in Canada by level of LLA, per 100 000 individuals. Age-standardized to final post-censal Canadian population in 2011, direct method. Transtibial/transfemoral incidence ratio: 2006 = 1.28; 2007 = 1.24; 2008 = 1.22; 2009 = 1.32; 2010 = 1.28; 2011 = 1.41

lowest rates belonged to ankle and hip and pelvis amputations (0.1 and 0.2 per 100 000 respectively). The transtibial/transfemoral incidence ratio increased from 1.28 in 2006 to 1.41 in 2011 (Figure 2). In terms of cause of amputation, diabetes-related amputations were the highest, with an average age-adjusted incidence rate of 15.0 per 100 000 (Figure 3). The second most common cause of amputation was the “other vascular diseases/infections” category (5.9 per 100 000) followed by trauma-related amputations (1.3 per 100 000).

Tertiary Objective

The average age-adjusted incidence rate of LLA among people with diabetes was 280.5 per 100 000, whereas for people without diabetes it was 9.7 per 100 000 (relative risk = 28.9).

DISCUSSION

This is the first study to report on the age-adjusted incidence rates of LLA in Canada and the 10 provinces by sex, level, and cause of amputation. The results showed a decline in the age-adjusted incidence rates over the six-year period studied. Similarly, in all provinces, except for Alberta and British Columbia, the age-adjusted LLA incidence rates declined. On average, the overall age-adjusted incidence rate was 2.6 times greater among males than females. The age-adjusted transtibial to transfemoral incidence ratio showed an increase from 1.28 in 2006 to 1.41 in 2011. The main cause of LLA was diabetes (65% of LLAs). The relative risk of LLA was 28.9 times greater in people with diabetes than in people without diabetes.

The overall age-adjusted rate in our study (22.9 per 100 000) was larger than that of some Western countries, such as the

Figure 3. Age-adjusted LLA incidence rates in Canada by cause of LLA, per 100 000 individuals. Age-standardized to final post-censal Canadian population in 2011, direct method

Netherlands (8.8 per 100 000 in 2004),⁴ and smaller than that of others (92.5 per 100 000 in 2009), such as Ireland.⁵ The observed downturn in the age-adjusted LLA incidence rates is consistent with the recent literature.⁶⁻⁸ In the US, the rates were reported to have declined from 2000 to 2010.⁶ It is difficult to meaningfully compare the rates across countries because different methods have been employed for reporting the incidence rates. For example, there are differences in defining the numerator and the denominator of the incidence rates. It is unclear from some of the studies how the LLA cases were defined and counted. The heterogeneity and the lack of clarity in the methods of these studies are perhaps due to the complexity of determining LLA incidence and the current lack of consensus on the methods for reporting LLA incidence rates.^{3,20} Information on how the count has been derived is important because LLA is an event that can happen more than once in an individual, at five different levels and in both limbs. Therefore, depending on how the cases are defined and counted, the results can differ notably from study to study. According to a protocol of a systematic review by Kvitkina et al.²¹ on diabetes-related incidence rates, there are three methods for counting the number of LLA cases and therefore determining the numerator: 1) person-level: when only one amputation per person is counted; 2) case-level: when only one amputation per limb on the same admission is counted but amputations on different admissions are counted separately; and 3) procedural-level: when all amputation procedures regardless of whether carried out at the same or different admissions are counted separately. In this study, we chose to report the data based on case level because it was compatible with the incidence studies that had clear methods.^{6,22} In addition, some of the patient identification codes were missing from our data, which made it difficult to determine person-level incidence rates. We also think that person-level counts may ultimately underestimate the incidence and the burden of LLA because each person is counted only once, regardless of the number of LLAs that may have been carried out. On the other hand, procedural-level counts may overestimate the incidence of LLA because all amputation procedures carried out will be counted. For example, using procedural-level counts, if a patient is admitted for an ankle amputation on the right limb and instead is discharged with a transtibial amputation on the same limb this would be

counted twice. There are also differences across studies in the choice of the denominator (e.g., total population versus population at risk), which can entirely change the incidence rates and make comparisons more challenging.³ Given the complexity of and the differences in reporting LLA incidence rates, it is important that a consensus is reached on the use of a single reporting method so that the rates can be easily compared across studies and future systematic reviews and meta-analyses can be carried out.

It is interesting that although the age-adjusted LLA incidence rates have declined, the total number of new cases of LLAs increased in our study. A closer look at our data showed that because the Canadian population grew from 2006 to 2011, the size of the denominator used in calculating the incidence rates increased as well. As a result, because the size of the population has grown faster than the number of LLAs, the rates have declined despite the increase in the total number of LLAs. Other studies have reported similar trends. In a study that investigated the vascular-related LLA incidence rates among older adults in the United States from 1956 to 1995, the authors reported a decline in the LLA incidence rates but an increase in the total number of LLAs.²³ Likewise, Dawes et al. reported similar findings for the LLA incidence rates in Quebec.⁸

Consistent with previous reports from other regions, the calculated incidence rate of LLA was greater among males than females.^{8,24,25} This higher incidence among males is partly due to the fact that vehicle- and work-related accidents, the main contributors of traumatic LLAs, are more common among males.² Furthermore, the rates of diabetes and vascular diseases are generally greater among males.¹¹

Diabetes accounted for more than 65% of the LLAs in our study. Despite the fact that diabetes-related LLA incidence rates remained relatively stable in our study, the number of new LLAs due to diabetes increased by 13% over the study years. Similar trends were reported for the United Kingdom between 2004 and 2008.²² It is well known that individuals with diabetes have an inherent risk factor for foot disease.² The nerve damage caused by diabetes can cause numbness and prevent the individual from feeling an injury. Furthermore, the lack of blood flow associated with diabetes-related peripheral vascular disease impedes the healing of ulcers and foot infections, which can lead to LLA. Proper foot screening and aggressive treatment of infections help prevent the occurrence of LLAs in this population.²⁶ In 2007, 51% of individuals in Canada met the clinical guidelines for physicians' foot examinations, and this number continues to grow.^{27,28} Though this is encouraging, more prevention efforts need to be done to halt the increase in diabetes-related LLAs in Canada.

In terms of rates by Canadian provinces, our results showed that although the age-adjusted incidence rates continued to decrease for all provinces except for Alberta and British Columbia, the province of Newfoundland and Labrador showed the highest LLA rates compared with other provinces. This could be because the age-adjusted diabetes rate and diabetes risk factors such as obesity are reported to be the highest in this province (diabetes rate = 8.3%; obesity and overweight rate = 74.6%) compared with other provinces in Canada.¹¹ British Columbia and Quebec had the lowest LLA rates, which may be because of their lower diabetes and obesity rates.¹¹ However, despite the fact that British Columbia had one of the lowest age-adjusted rates, it showed a 16% increase in

the number of new LLAs from 2006 to 2011. Likewise, in Alberta there was a 23% increase in the number of new LLAs from 2006 to 2011. Statistics Canada shows that despite the historically lower rates of diabetes in these two provinces, the incidence of diabetes is increasing in British Columbia and Alberta, perhaps because of their higher concentrations of certain ethnic groups, such as South Asians and Chinese, that generally have higher risk factors for diabetes.¹² This increase in the incidence of diabetes may explain the observed growth in the number and incidence of LLA in these two provinces.

Recent reports in the United States have shown a greater decline in proximal LLAs (e.g., transfemoral) than distal (e.g., transtibial) LLAs.⁶ This is consistent with our study results, which showed an increase in the ratio of transtibial to transfemoral amputations. Distal LLAs and the preservation of the knee joint are advantageous over proximal LLAs because they are associated with reduced mortality and healing time, decreased costs, shorter rehabilitation time, and greater possibility of achieving prosthetic walking and independence for the individual. Optimally, the transtibial to transfemoral incidence ratio should be no less than 2.5.^{29,30} In the current study, this ratio was below the optimal level; however, the transtibial to transfemoral incidence ratio continued to increase over time, which indicates a decrease in the number of transfemoral amputations and perhaps surgeons' increased efforts to preserve the knee joints. Future studies should investigate whether this trend will help reduce mortality and complications and increase prosthetic walking in this population.

The increase in the number of LLAs observed in our study has important implications for the Canadian health care system. Policy-makers need to be aware of the increase and the resultant demand for preventive and rehabilitative health resources. Preventive efforts against diabetes and chronic disease, early detection, and management should also be optimized.^{31–33} These resources should be evidence-based, cost-effective, and accessible to the individuals at risk.

Limitations

This study had a number of limitations. First, there were some missing data (~5%). For example, the patients' identification codes were missing in some of the cases, which made it difficult to count the number of individuals. Although missing data can affect the precision of the statistics, the amount of missing data in our study was small and therefore the influence is likely small. Second, it was hard to determine the definitive cause of LLA because the direct cause of amputation was not reported. To address this, we reviewed the patient's list of diagnoses to derive the most probable cause of amputation. Despite our effort to identify the most likely cause, there is a possibility for misclassification, particularly for the "other vascular diseases/infections" category. As an example, when a hospitalization record had both "vascular disease/infection" and "trauma" codes, we gave preference to trauma having been the probable cause of the amputation with an assumption that the infection was likely to have originated because of an accident. It is important that for future cases of LLAs the correct cause of the amputation be recorded and reported to the CIHI to minimize the possibility of misclassification bias.

Another limitation is that although we reported on the relative risk of LLA in people with diabetes compared with those without

diabetes, there is a degree of bias associated with this estimate because it relies on knowing the true prevalence of diabetes in Canada, which is often very difficult to determine. Third, CIHI releases data based on fiscal years, whereas Statistics Canada provides population data based on annual years. Thus, the calculated yearly incidence rates do not entirely reflect the annual rates or the fiscal rates.

CONCLUSION

This study provided the first Canadian national and provincial age-adjusted incidence rates of LLA and a baseline for monitoring and evaluating in the future. Although the age-adjusted LLA incidence rates decreased from April 1, 2006, to March 31, 2012, the number of diabetes-related LLAs increased by 13%. The increase in the number of diabetes-related LLAs has important implications for social and health care costs. With the growing aging population and the expected growth in the number of individuals living with LLA, it is imperative that adequate rehabilitation resources, foot screening, and diabetes management programs are available to this population and are allocated appropriately.

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Received: January 25, 2017

Accepted: May 12, 2017

RÉSUMÉ

OBJECTIFS : Déterminer les taux d'incidence des amputations de membres inférieurs (AMI) rajustés selon l'âge au Canada par province, par sexe, par niveau et par cause d'amputation.

MÉTHODE : Les données sur les sorties de l'hôpital associées aux AMI entre le 1^{er} avril 2006 et le 31 mars 2012 proviennent de la Base de données sur les congés des patients de l'Institut canadien d'information sur la santé. Les taux nationaux et provinciaux rajustés selon l'âge ont été calculés pour 100 000 habitants par sexe, par niveau et par cause d'AMI selon la méthode de standardisation directe. Le risque relatif d'AMI chez les personnes diabétiques a aussi été calculé.

RÉSULTATS : En tout, 44 430 AMI ont été effectuées au Canada au cours de la période à l'étude. Le nombre d'AMI a augmenté, passant de 7 331 en 2006 à 7 708 en 2011. L'âge moyen (SD) des patients était de 65,7 ans (16,6), et 68,8 % étaient des hommes. Soixante-cinq p. cent des cas d'AMI étaient dus au diabète. Le taux moyen d'AMI rajusté selon l'âge au Canada était de 22,9 pour 100 000 habitants. Les taux rajustés selon l'âge ont baissé au cours des années de l'étude. Le risque relatif d'AMI liée au diabète était de 28,9.

CONCLUSION : Cette étude est la première à fournir les taux d'incidence des AMI nationaux et provinciaux rajustés selon l'âge au Canada et constitue une base de référence pour en faire le suivi et l'évaluation à l'avenir. Il est essentiel de comprendre l'incidence des AMI pour gérer les services de prévention et de réadaptation dans la population en question. Bien que les taux d'incidence des AMI rajustés selon l'âge aient diminué, le nombre de nouvelles AMI augmente. Cette augmentation a d'importantes répercussions sur les coûts des soins de santé et des services sociaux.

MOTS CLÉS : Incidence; épidémiologie; amputation; diabète; Canada