Estimation of the lifetime risk of hip fracture for women and men in Canada

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Abstract

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Conflicts of interest None.

Summary—In Canada in 2008, based on current rates of fracture and mortality, a woman or man at age 50 years will have a projected lifetime risk of fracture of 12.1% and 4.6%, respectively, and 8.9% and 6.7% after incorporating declining rates of hip fracture and increases in longevity.

Introduction—In 1989, the lifetime risk of hip fractures in Canada was 14.0% (women) and 5.2% (men). Since then, there have been changes in rates of hip fracture and increased longevity. We update these estimates to 2008 adjusted for these trends, and in addition, we estimated the lifetime risk of first hip fracture.

Methods—We used national administrative data from fiscal year April 1, 2007 to March 31, 2008 to identify all hip fractures in Canada. We estimated the crude lifetime risk of hip fracture for age 50 years to end of life using life tables. We projected lifetime risk incorporating national trends in hip fracture and increased longevity from Poisson regressions. Finally, we removed the percentage of second hip fractures to estimate the lifetime risk of first hip fracture.

Results—From April 1, 2007 to March 31, 2008, there were 21,687 hip fractures, 15,742 (72.6%) in women and 5,945 (27.4%) in men. For women and men, the crude lifetime risk was 12.1% (95%CI, 12.1, 12.2%) and 4.6% (95%CI, 4.5, 4.7%), respectively. When trends in mortality and hip fractures were both incorporated, the lifetime risk of hip fracture were 8.9% (95%CI, 2.3, 15.4%) and 6.7% (95%CI, 1.2, 12.2%). The lifetime risks for first hip fracture were 7.3% (95%CI, 0.8, 13.9%) and 6.2% (95%CI, 0.7, 11.7%).

Conclusions—The lifetime risk of hip fracture has fallen from 1989 to 2008 for women and men. Adjustments for trends in mortality and rates of hip fracture with removing second fractures produced non-significant differences in estimates

Keywords

Hip fractures; Life tables; Mortality; Osteoporosis; Risk

Introduction

Hip fractures pose a serious morbidity and mortality burden on individuals and society. There were over 28,000 hospitalizations for hip fractures in Canada in 2007 [1]. Each hip fracture typically results in a hospitalization that lasts more than 10 days [2] and is often followed by prolonged rehabilitation, with less than half of patients with hip fracture regaining their ability to perform activities of daily living [2]. In addition, the absolute rate of mortality in Canada for hip fractures was 23.5% at 5 years [3], and if a second hip fracture occurs, the mortality rate can be 66.5% at 5 years [4]. Hip fractures can also have a substantial financial toll. The average cost of care following a hip fracture can be over \$44,000 [2]. In 2008, the acute care costs of hip fracture in Canada was 650 million CAN \$ [5].

For public providers of health care, being aware of the health care burden and knowing the return on investment through adopting cost-effective strategies that reduce hip fractures would be important. For example, vitamin D and bisphosphonates have been shown to reduce fractures and falls [6–8], and funding drugs to seniors may be more cost-effective than spending future health care dollars on fracture care and institutionalization [9].

Similarly, screening programs that seek to prevent first or second hip fractures can be cost-effective [10]. For this type of analysis, lifetime fracture estimates of risk are required to build an economic model for evaluating policy trade-offs [11].

One method to estimate the lifetime risk of fracture is to longitudinally track a cohort over their lifetimes and count the number of individuals with a hip fracture. However, this method would not represent the projected future risk of hip fracture, as rates of hip fracture and rates of mortality by age may have change over time. Alternatively, one could simulate a life profile using the prevalence-based life table method. The life table is constructed with a hypothetical cohort who, for example, is 50 years old today, and their risk of hip fracture for the remaining years of their life is subject to the age–sex-specific rates of hip fractures experienced by an actual population during the past year. The lifetime risk of hip fracture is then estimated by combining the probabilities of surviving into the next years for each age with the probabilities of having had a hip fracture for each age. This type of analysis has been conducted in 1989 for Canada which estimated the lifetime risk of hip fracture to 14.0% for women and 5.2% for men [12–14], but, to our knowledge, this estimate has not been updated.

Since 1989, there have been changes in the levels of risk factors such as use of tobacco, alcohol, and rate of obesity which is a protective factor [15, 16]. Providing a current life table estimate would be important to provide a comparison to the earlier value for Canada, but a life table method using the same method may not truly reflect a person's expected future risk. The problem is that a life table incorporates the rates of mortality and hip fracture at each age and sex assuming them to be constant. For example, the expected rate of hip fracture for a 50-year-old in 10 years at age 60 years is assumed to be the same rate as a 60-year-old today. However, the age–sex rates of hip fractures in Canada have been changing over time [17] and have been declining at a faster rate in recent years. In addition, the rates of mortality and thus exposure to hip fractures have also been decreasing over time as life expectancy has been almost constantly increasing every year in this century. To provide an accurate prediction of the future risk profile for hip fracture, the trends in the rates of hip fracture and the trends in mortality should be incorporated.

A further problem with the life table method is the possibility of a person having a repeated event. The life table method assumes the risks estimated by age–sex are for unique individuals, yet we know that there exists a probability of second hip fracture. The rate of second hip fracture within 10 years after the first fracture has been estimated to be about 10% [18]. To estimate the lifetime risk of having a first hip fracture, the lifetime risk estimate needs to remove the percentage of hip fractures that are second hip fractures.

This paper addresses the question ‘what is the current expected lifetime risk of hip fracture for men and women in Canada?’ We first provided an estimate of lifetime risk of hip fracture with a life table to compare with the earlier value. Next, we estimated the expected future experience for a 50-year-old today incorporating predicted trends in the rates of hip fracture and mortality into the life table estimates. We estimated the life table risk by incorporating trends that have occurred over a longer period, and then we re-estimated the lifetime risk

using more recent trends. In addition, we estimated the lifetime risk of first hip fracture by incorporating from the literature the percentage of hip fractures that are second hip fracture.

Methods

Primary data source

We used national administrative healthcare data from the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD) which provides data on all acute care hospitalizations that occur in Canada except for the province of Quebec (23% of the Canadian population) [19]. These data have been validated and show high sensitivity and specificity for hip fracture diagnoses and fracture interventions [20]. National numbers of hip fractures for each year of age and gender were extrapolated from the CIHI-DAD database after adjusting for the missing Quebec data using the gender and age population structure of Quebec relative to the rest of the country.

Identification of fractures

We identified hip fractures between April 1 2007 to March 31, 2008 based on International Classification of Diseases (ICD) version 10 (ICD-10 CA) diagnosis codes [21]. Specific anatomical sites of interest based on ICD-10 CA codes were S72.0 (fracture of the neck of the femur), S72.1 (pertrochanteric fracture which includes intertrochanteric fracture and trochanteric fractures), and S72.2 (subtrochanteric fracture). A Canadian Classification of Health Interventions (CCI) interventional code for the fixation and implantation of an internal device, an open or closed reduction, immobilization, or partial excision at hip fractures sites was also required. We excluded hospitalizations that did not have an intervention (these may indicate initial admission to a center without surgical facilities with subsequent transfer to a surgical center, or re-admission following an intervention for rehabilitation or complications).

Estimating fracture risk

The primary outcome was the life table estimate of risk of hip fracture for men and women beginning at age 50 years until the end of life. In Canada, the life expectancy is approximately 83 for women and 78 years for men, and life expectancy after reaching age 65 years is another 21.3 in women and 18.1 years in men [22]. The life table estimate [23] provides an estimate at age 50 years in the year 2008 for the general population of the expected lifetime risk of hip fracture where death is a competing risk [23]. To estimate these risks, we generated the age- and gender-specific rate of having a hip fracture as number of fractures per population at risk from national census data [24]. Next, using the life table method, we summed the probability of survival at age multiplied by the probability of a hip fracture.

Statistical analysis

The lifetime risk of hip fracture was estimated without and then with adjustments for trends in mortality, for trends in rates of hip fracture, and for recurrent hip fractures. To predict the future trends in age-gender-specific mortality, two time periods were evaluated. The first period included the longer-term trends in mortality for available years 1991 to 2008 for the

national population using census data [22], and the national trends in the rates of hip fracture was provided for years 1985 to 2006 [17]. The second period included recent trends that occurred in the period 2001 to 2007 only since the trend in rates of hip fractures has changed since 2001. Both trends in mortality and hip fracture were derived with Poisson regression, as described in the technical appendix of earlier work [25]. Linear trends were also investigated, and based on regression diagnostics, the linear regression predictions fit the data as well as Poisson regression trends, but the predictions were not sensible, and the results are not presented.

Finally, to account for the chance that a person may experience two hip fractures during their lifetime, we estimated the lifetime risk of a first hip fracture. National data on the rate of second hip fractures is not available. To account for second hip fractures, we applied the literature values from one study from Denmark that provided rates of second hip fracture by age and gender [26]. The percentage of hip fractures that are first fracture was 80.6% for women age 50 years declining to 77.2% for ages 90 years and over, and 85.7% for men age 50 years declining to 79.6 for ages 90 years and over. These rates were used to reduce the rates of hip fractures to estimate the life time risk of first hip fractures.

Uncertainty—Uncertainty existed for rates of hip fractures, mortality, second hip fracture, regression prediction errors, and life table summation errors. For rates of hip fractures, mortality, and second hip fracture, a binomial approximation was made for the estimated variance. From the regression prediction for future rates of hip fracture and mortality, the standard error of the prediction was derived. When constructing the life table, the uncertainty of rates of hip fractures and mortality were combined under the assumption of independence as random variables. Means and standard errors are reported for prediction trends, and means and 95% confidence intervals (95%CI) are reported for final estimates. We conducted the analysis in Microsoft Excel 2010 and STATA 11.0 SE [27].

Results

Between April 1 2007 and March 31, 2008, there were 21,687 hip fractures in Canada for age 50 years and over that required hospitalization and a surgical procedure, of which 15,742 (72.6%) were in women and 5,945 (27.4%) were in men. For the hip fractures, the most common procedures were fixation (60.4%), and implant internal device (38.0%); immobilization, reduction, and partial excision each contributed less than 1%. There were 1,283 unique admissions (5.6% of all admissions) that did not require surgery and were excluded.

Descriptive statistics of rates of hip fracture by age and gender

Table 1 lists the numbers and rates of hip fracture by gender and age groups. The rate of hip fracture increased from age 50 years for both men and women, and this was particularly striking after age 70 years. Most hip fractures occurred between the ages 80 to 90 years for both women and men, though the rate of fracture per population was highest after age 90 years. In women, 664% of hip fractures occurred after the age of 80 years and 17% occur after the age of 90 years (48% and 10% for men, respectively). The simple sum of the age-specific rates of hip fracture for women was 18.4% at age 90 years (2.9% for all ages

including age 100+) and for men 10.4% at age 90 years (27.9% for 100+). The cumulative risk translated into approximately one in five women and one in ten men. The lifetime fracture risk for women assuming reaching age 90 years were 12.0% for the neck of the femur, 9.8% for pertrochanteric, and 1.3% for subtrochanteric (7.2%, 5.7%, and 1.0% for men).

Trends in the rate of mortality and hip fracture

To account for trends in the rate of mortality, the exponential trend in age–gender-specific mortality was estimated for the years 1991 to 2007 as between 1% and 3% depending on the age group (see Table 2). For women, the rate of decline of hip fracture was higher than the decline in rate of mortality at all ages. For men, the opposite was true with the decline in the rate of hip fracture being lower than the rate decline in the rate of mortality at all ages. Figure 1 shows the actual and projected rates of mortality and hip fracture for ages 85 years and over until the year 2020. The rates of decrease in mortality are similar, while the rate of hip fracture for women is falling faster than the decline in the rate of mortality.

When we included only recent trends in the trends in hip fracture and mortality, there was a smaller difference in the rate of hip fracture relative to mortality for women for most of the age groups. For men, the trends were similar to the long-term trends, except for age 85 years and over where in the recent period, the decline in the rate of hip fracture is higher than the decline in the rate of mortality.

Lifetime risk of hip fracture

The life table estimate for the risk of hip fracture women was 12.1% (95%CI, 12.1% to 12.2%) and for men 4.6% (95%CI, 4.5% to 4.7%; Table 3). Applying the declining trend for hip fracture alone decreased the estimated life time risk of hip fracture to 5.6% (95%CI, 0.7% to 10.5%) for women and 1.7% (95% CI, 0.0% to 7.0% for men. Applying the declining trend for mortality alone increased the estimated life time risk of hip fracture to 18.8% (95% CI, 14.5% to 23.3%) for women and 10.9% (7.2% to 14.0%) for men. When declining rates hip fracture and of mortality were both applied, the lifetime risk of hip fracture was 8.9% (95% CI, 2.3% to 15.4%) for women and 6.7% (95% CI, 1.2% to 12.2% for men. Finally, when the number of fractures was adjusted downward by the proportion of fractures by age and gender that are only first fractures, the lifetime risk of first hip fracture was 6.8% (95% CI, 0.3% to 13.4%) for women and 6.2% (95% CI, 0.7% to 11.7%) for men.

Similarly, the estimate for the lifetime risk of hip fracture using the most recent trends was estimated with adjustment for trends in mortality, rates of hip fracture, and second fractures. For women, the risk is lower, while for men the risk of lifetime hip fracture is unchanged. However, the confidence intervals for the predications using the most recent data are wider than the confidence intervals for prediction over the longer trend, and these differences are not significant

Discussion

In 1993, Melton provided an estimate of the lifetime risk of hip fracture if a person lived to reach age 90 years as one in three women and one in nine men for the USA [28], while we

estimate one in five for women and one in ten for men. The United States estimate was derived from the simple cumulative sum of the risk of fracture at each age. In Canada, the lifetime risk based on life table methods during similar years was 14.0% for women and 5.2% for men [12–14]. In 2008, we estimated the unadjusted life table lifetime risk of hip fracture was lower at 12.1% for Canadian women and 4.6% for Canadian men. When projected rates of mortality and hip fracture were both included in the estimation, the lifetime risk of hip fracture was not significantly different for women or men.

The declining risk of hip fracture has also been reported in the USA [29] and follows a similar pattern to Canada. In addition, during the period 1986 to 2005, there was a break in the association of hip fracture and mortality. Before 1995, both the rates of hip fracture and mortality after hip fracture were decreasing. Since 1996, the rate of hip fracture continued to fall, but the rate of mortality after a hip fracture remained constant while overall mortality rates continued to decline. In France, overall mortality is falling faster than fracture-related mortality [30], and the risk of mortality following a hip fracture is still a great concern. Moreover, declining risk in hip fracture has not been achieved in other countries [29].

Factors that may have contributed to decreased population risk of hip fracture in Canada and the USA include the increased use of calcium and vitamin D supplements and recent introduction and uptake of bisphosphonates among other osteoporosis medications [31]. The first bisphosphonate introduced in Canada was etidronate in 1995 followed by alendronate in 1998. In 2005, alendronate became generic, which introduced a large increase in the uptake of these drugs. Lifestyle changes have also occurred such as a decrease in smoking in Canada from 35% in 1993 to 21% in 2009, while the percent of the population that would be classified as obese by body mass index has increased [16]. However, analysis that included the above factors has not been able to account for all of the changes in the risk hip fractures elsewhere [7].

One negative consequence of reduced fracture rates and increased longevity is that hip fractures may occur at a later age. This is concerning because with longevity there is an increased risk of developing comorbidities such as dementia, diabetes, and peripheral neuropathy which are known predictors of falls and fractures [8]. In addition, the rate of mortality and costs of hip fractures increases with the number of comorbidities and age. In addition, the rate of morbidity, mortality, and costs following an intertrochanteric fracture, which has an increased proportion of total hip fractures with age for both women and men, is higher than other hip fractures sites [8].

Despite these qualifications, the overall pattern of declining risk of hip fracture and mortality is hopeful for society. However, for the individual patient, the immediate period of 10 years is more urgent and now the target of new fracture prediction by the World Health Organization's fracture assessment tool (FRAX) [32]. Still, for society the estimate of lifetime risk of hip fracture is more relevant for public health policy and making projections.

The strengths of this analysis are that we relied on national data for hip fractures and mortality over a common period, and we identified fractures from mandatory reporting in our public health care system. There are also limitations. One limitation was that we used

the rates of second hip fracture from a different country and time period, although similar estimates of the rate of second hip fractures are found elsewhere [18, 33]. Future research on whether the percent of fractures that are first or second by age is changing over time would be helpful. Another limitation was in the projection of the rates of hip fractures and mortality into the future, which is admittedly uncertain and could continue, stabilize, or even reverse.

Statistics Canada predicts that the population over age 80 years will increase by an average rate of 6.4% per year until the year 2041 [22]. While the rate of hip fractures have been declining for women and less so for men, there will be a rise in the absolute numbers of hip fractures. If the risk of hip fracture can continue to decline or further accelerate, some mitigation of the burden due to the increased numbers of hip fracture arising from an aging population may occur.

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Fig. 1.

Trends in rates of mortality and hip fracture, predicted to year 2020, for ages 85+years. For women, the rate of decline for hip fractures is higher than the rate of decline for mortality while, for men, the rate of decline for hip fractures is less than the rate of decline for mortality

Table 1

Number and rates of hip fractures for age group and gender

Age group, years	Women		Men	
	Population	Hip fractures, <i>n</i> (annual rate%)	Population	Hip fractures, <i>n</i> (annual rate%)
51 to 60	2,302,817	556 (0.0%)	2,254,334	521 (0.0%)
61 to 70	1,526,056	1,281 (0.1%)	1,445,481	835 (0.1%)
71 to 80	1,028,925	3,829 (0.4%)	857,457	1,742 (0.2%)
81 to 90	596,906	7,424 (1.2%)	350,175	2,223 (0.6%)
91 +	112,863	2,652 (2.3%)	38,977	624 (1.6%)
Cumulative, 80 years	4,857,798	5,666 (4.3%)	4,557,272	3,098 (3.0%)
Cumulative, 90 years	5,454,704	13,090 (15.6%)	4,907,447	5,321 (9.8%)
Cumulative, all years	5,567,567	15,742 (42.9%)	4,946,424	5,945 (25.8%)

Annual rate percent indicates average annual rate of fracture. Cumulative indicates from 50 to 80 years, 50 to 90 years, etc.

Annual trends in the changes in rate of mortality, hip fracture, and difference between mortality and hip fracture, by age groups and gender for Canada

Table 2

	Women			Men		
	Mortality (M)	Fractures (F)	Difference (F–M)	Mortality (M)	Fractures (F)	Difference (F–M)
Long-term trends derived from the years 1985 to 2007						
<55 years	–1.41 (2.32)%	–1.71 (5.15)%	–0.30 (5.65)%	–1.80 (2.94)%	–0.93 (3.77)%	0.86 (4.78)%
55 to 64 years	–1.75 (1.62)%	–3.62 (1.35)%	–1.87 (2.11)%	–2.53 (2.11)%	–1.89 (1.57)%	0.64 (2.63)%
65 to 74 years	–1.52 (1.00)%	–2.32 (0.69)%	–0.79 (1.21)%	–2.66 (1.32)%	–1.39 (0.92)%	1.27 (1.60)%
75 to 84 years	–1.44 (0.62)%	–1.54 (0.34)%	–0.10 (0.70)%	–2.16 (0.78)%	–1.16 (0.49)%	1.00 (0.92)%
85+ years	–0.65 (0.38)%	–1.09 (0.20)%	–0.44 (0.43)%	–1.04 (0.43)%	–0.62 (0.27)%	0.42 (0.51)%
Recent trends derived from the years 1997 to 2007						
<55 years	–1.07 (5.89)%	0.50(20.89)%	1.58 (21.70)%	–1.03(4.66)%	0.04(14.63)%	1.07(15.35)%
55 to 64 years	–1.78 (4.21)%	–2.02(5.56)%	–0.25(6.97)%	–2.35(3.27)%	–0.55(6.12)%	1.80(6.94)%
65 to 74 years	–1.87 (2.61)%	–2.41(2.67)%	–0.55(3.73)%	–3.19(2.00)%	–2.50(3.48)%	0.69(4.01)%
75 to 84 years	–1.97 (1.55)%	–2.29(1.29)%	–0.32(2.02)%	–2.98(1.23)%	–1.74(1.84)%	1.25(2.21)%
85+ years	–1.53 (0.83)%	–1.81(0.76)%	–0.29(1.13)%	–2.01(0.74)%	–2.38(1.00)%	–0.37(1.24)%

Means (standard errors) from standard errors of prediction from Poisson regressions

Example: For age 85+ years for women during the years 1985 to 2007, the rate of mortality has been declining by –0.65% per year; the rate of hip fractures has been declining –1.09% per year, and rate of hip fracture is falling faster than the rate of mortality by –0.44% per year

Table 3

Estimated lifetime risks of hip fracture using prevalence-based life tables under different assumptions

Based on trends from the years 1985 to 2007		
Life table estimate of lifetime hip fracture	Women	Men
Unadjusted	12.14% (12.07% to 12.21%)	4.58% (4.51% to 4.66%)
Adjusted for longevity	18.79% (14.45% to 23.13%)	10.68% (7.15% to 14.22%)
Adjusted for fracture trends	5.64% (0.74% to 10.53%)	2.76% (0% to 6.97%)
Adjusted for longevity and fracture trends	8.85% (2.31% to 15.39%)	6.70% (1.21 to 12.20%)
Adjusted for second fracture	9.40% (9.07% to 9.73%)	3.75% (3.30% to 4.21%)
Adjusted for second fracture, longevity, and fracture trends	6.83% (0.28% to 13.38%)	6.18% (0.67% to 11.69%)
Based on trends from the years 1997 to 2007		
Life table estimate of lifetime hip fracture	Women	Men
Unadjusted	12.14% (12.07% to 12.21%)	4.58% (4.51% to 4.66%)
Adjusted for longevity	21.14% (12.46% to 29.82%)	12.10% (4.98% to 19.21%)
Adjusted for fracture trends	5.19% (0% to 26.09%)	2.11% (0% to 18.42%)
Adjusted for longevity and fracture trends	8.68% (0% to 31.31%)	4.49% (0% to 22.28%)
Adjusted for second fracture	9.40% (9.076% to 9.73%)	3.75% (3.30% to 4.21%)
Adjusted for second fracture, longevity, and fracture trends	6.71% (0% to 29.34%)	3.65% (0% to 21.45%)

Risks (95% confidence intervals)