The Burden of Illness of Osteoporosis in Canadian Men

Jean-Eric Tarride,1,2 Na Guo,1,2 Robert Hopkins,1,2 William D Leslie,3 Suzanne Morin,4 Jonathan D Adachi,5 Alexandra Papaioannou,5 Louis Bessette,6 Jacques P Brown,6 and Ron Goeree1,2

1Programs for Assessment of Technology in Health (PATH) Research Institute, St Joseph’s Healthcare, Hamilton, Ontario, Canada
2Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada
3Department of Medicine, University of Manitoba, Winnipeg, Manitoba, Canada
4Department of Medicine, McGill University, Montréal, Quebec, Canada
5Department of Medicine, McMaster University, Hamilton, Ontario, Canada
6Department of Medicine, Laval University, Quebec City, Quebec, Canada

ABSTRACT
There is a dearth of information about the burden of osteoporosis in Canadian men. To fill this gap, we conducted a burden of illness study aimed at estimating the economic burden attributable to osteoporosis in Canadian men aged 50 years and older. Five national data sources were used to estimate health care resource utilization and costs (in 2010 Canadian dollars) associated with osteoporosis in men. Any information gap was supplemented by using data from provincial and community sources. Direct medical costs included costs associated with hospitalizations, same day surgeries, emergency room visits, rehabilitation, chronic care, long-term care, home care, physician visits, and prescribed medications. The value of lost productivity from patients and informal caregivers was also determined to provide a societal perspective. Sensitivity analyses were conducted to evaluate the impact of key assumptions on the results. In fiscal year 2007/2008, the total economic burden of treating and rehabilitating male osteoporotic fractures was estimated at $570 million per year, where direct medical costs accounted for 86%. Acute care utilization was responsible for 70% of all direct costs. About 51% of all hospitalizations were for hip fractures and hip fractures alone accounted for 54% of the acute care spending. If a proportion of Canadian men were assumed to live in long-term care facilities due to osteoporosis, the overall annual cost of osteoporosis would increase from $570 million to $910 million. Male osteoporosis has a substantial economic burden on the Canadian society. © 2012 American Society for Bone and Mineral Research.

KEY WORDS: OSTEOPOROSIS; FRACTURE; MEN; BURDEN OF ILLNESS

Introduction
Although osteoporosis is traditionally considered a condition affecting women, epidemiological and observational studies have shown that male osteoporosis is also associated with significant morbidity and mortality.1–5 Approximately 25% to 30% of all hip fractures in Canada6 and in Australia7 or among people aged 35 years and older worldwide1,8 are estimated to occur in the male population. Furthermore, up to 50% of men who sustain hip fractures need institutionalized care, with only 41% recovering to their pre-fracture functioning level.4,5 Due to the aging population and increased life expectancy, the burden of male osteoporosis is expected to grow substantially in the future. It has been predicted that the total number of hip fractures in men will be similar to current estimates in women by 2025.11–3 Although several studies have documented the burden of fractures of osteoporosis in men,8–14 many were limited in scope (eg, only acute care costs)8,9,11,12 and only one was conducted in Canada.14 In the only Canadian study to date, all incident fractures occurring in Manitoba during the period of 1996 to 2006 were identified and 1-year healthcare costs were calculated pre- and post-fracture.14 Although the results demonstrated that fractures in men were associated with a large incremental cost, this study was conducted in a province accounting for only 3.5% of the Canadian population, which limits the generalizability of these results. In addition, the results were not osteoporosis-specific.

In Canada, the annual health care expenditure due to osteoporosis and osteoporosis-attributable fractures in both men and women aged 45 years and older was calculated at $1.3 billion in 1993 ($1.8 billion in 2010 dollars).15 However, the cost specific to the male population was not presented.15 Since the publication of this study, which was conducted almost 20 years ago, the Canadian population has aged and there have been
many changes in the treatment, prevention and management of osteoporosis. To help clinicians, policy makers, and health care organizations better understand the clinical and economic implications of male osteoporosis, we conducted a burden of illness (BOI) study of osteoporosis among Canadian men. This is important because recent Canadian data have shown that in comparison to women, there exists a larger care gap in the diagnostic and treatment of fragility fractures and osteoporosis in men.

**Methods**

**Study design**

A prevalence approach was used to determine the burden of osteoporosis in Canadian men aged ≥50 years for the fiscal year starting April 1, 2007 and ending March 31, 2008 (FY 2007/2008). Where possible, national data estimates were used. When national estimates were not available, provincial and community data were extrapolated to the national level based on population demographic characteristics (ie, age and gender). The analyses were conducted from both a payer and a societal perspective. Costs were expressed in 2010 Canadian dollars. Sensitivity analyses were performed to assess the impact of key assumptions on the results.

**Data sources**

Medical service utilization data were collected from five databases maintained by the Canadian Institute for Health Information (CIHI): (1) Discharge Abstract Database (DAD) for information on hospitalizations; (2) National Ambulatory Care Reporting System (NACRS) for emergency room visits and same day surgeries; (3) National Rehabilitation Reporting System (NRS) for rehabilitation services; (4) Home Care Reporting System (HCRS) for home care; and (5) Continuing Care Reporting System (CCRS) for complex continuing care (eg, extended care or chronic care). Patient-level data were available for all databases including demographic (eg, age) and clinical (eg, diagnostic code) variables.

Outpatient physician services and prescription medication use associated with osteoporosis were estimated based on data provided by Intercontinental Marketing Services (IMS Health Canada) and Brogan Inc. respectively. Data from the Canadian Multicentre Osteoporosis Study (CaMos) and Statistics Canada were used to reflect a societal perspective (eg, patient and caregiver time loss). Gaps in data were supplemented by data from the Resident Assessment Instrument for Home Care (RAI-HC) of Ontario and from the Manitoba Centre for Health Policy population-based data repository for the Province of Manitoba.

**Identification of fractures attributable to osteoporosis**

All fractures that occurred in Canadian men aged ≥50 years during FY 2007/2008 were identified from CIHI databases according to two definitions: (1) a most responsible diagnosis code (International Classification of Disease [ICD]-10 or ICD-10-CA codes) of fracture at discharge (Table 1); or (2) a combination of a secondary ICD-10/ICD-10-CA code of fracture and an intervention indicative of treatment for a fracture (eg, fixation, immobilization, reduction, partial excision, and repair). A most responsible diagnosis code is defined by CIHI as “one diagnosis or condition that can be described as being most responsible for the patient’s stay in hospital.” Fractures secondary to severe trauma are unlikely to be manifestations of osteoporosis and were therefore excluded from the analyses. Among the remaining nontrauma fractures, all hip and vertebral fractures were assumed to be attributed to osteoporosis. The proportion of forearm, humerus, other and multiple fractures attributable to osteoporosis in men was assumed to be 56% based on U.S. data.

**Estimation of direct costs**

The methods used to estimate each category of acute care costs (ie, hospitalizations, same day surgeries, and emergency room

---

**Table 1. Diagnosis Codes of Fractures (ICD-10 CA)**

| Fracture site                        | ICD-10 CA code          |
|--------------------------------------|-------------------------|
| Hip                                  | S72.0, S72.1, S72.2     |
| Vertebral                            | S22.0, S22.1, S32.0     |
| Forearm                              | S52 with CCI codes      |
| Humerus                              | S42.2                   |
| Other sites                          |                         |
| Femur                                | S72.3, S72.4, S72.7, S72.8, S72.9 |
| Lower leg (tibia, fibula, ankle, knee, foot) | S82.0–S82.9, S92   |
| Lower arm (radius, ulna)             | S52 unless wrist above  |
| Other site (rib, shoulder, arm)      | S22.3, S42.0, S42.7, S42.8, S42.9 |
| Other fractures including:           | S22.2, S22.4, S22.8, S22.9 |
| Rib/sternum, clavicle, pelvis, patella, tibia/fibula, ankle | S32.1, S32.3, S32.4, S32.5, S32.7, S32.8, S42.0–42.9 except 42.2, S42.7, S42.8, S42.9, S72.0–72.9 except when “hip/femur” from above |
| Multiple fractures                   | T02.1–T02.9 (or more than 1 of above) |

ICD-10-CA = International Classification of Disease, 10th revision, developed by the World Health Organization and enhanced by CIHI to meet Canadian data need; CCI = Canadian Classification of Health Interventions.
visits) and non-acute care costs (ie, rehabilitation, chronic care, home care, physician services, and prescribed drugs) are described below. Costs were estimated as the product of the number of resources used and the relevant unit prices, which are presented in Table 2.

The number of hospital admissions due to osteoporosis-related fractures in men was estimated based on the DAD database, which covers 100% of all admissions in Canada with the exception of Quebec. The data for Quebec were therefore imputed from the remaining provinces based on population demographics (ie, age and gender). Although CIHI databases provide information on emergency room visits and same day surgeries for all Canadian provinces (except for Quebec), this information is only complete for Ontario. Ontario data on emergency room visits and same day surgeries were therefore extrapolated to the national level based on population demographics. Using DAD and NACRS data, the costs associated with hospitalization (which includes the cost of surgery), emergency visits, and same day surgeries were calculated by multiplying the resource intensity weights (RIWs)\(^{(31)}\)—a standard costing methodology developed by CIHI—attributed to each patient by the average cost per RIW ($5,399). Physician fees, surgical procedure costs and diagnostic test costs, which are not considered in RIWs, were estimated and added to the RIW cost estimation (Table 2).

Although CIHI databases (eg, NRS and CCRS) provide information on rehabilitation and continuing care, these databases do not record the most responsible diagnosis code for admission making it difficult to attribute the stay in these facilities to osteoporosis or a fracture. In addition, CIHI databases do not provide any information on long-term care. Therefore, to derive the number of admissions to rehabilitation, continuing care and long-term care facilities, DAD was used to estimate the number of male patients who were transferred from acute care to these facilities following a hospitalization due to an osteoporotic fracture. Individuals who had already been residents in these facilities prior to being hospitalized were excluded from the analyses as we were not able to identify the reason of admission to these facilities prior to the fracture. Only net transfers were accounted in the base case analyses (number of men discharged to a particular location – number of men originating from this particular location). Home care services following an osteoporosis-related fracture were imputed based on Ontario information from the CIHI-HCRS database.

Costs associated with rehabilitation and continuing care utilization were calculated on a per admission basis, by multiplying the excess number of men transferred to these facilities by the average NRS and CCRS’s RIW per admission adjusted for physician visit fees. In the absence of national data, information from Manitoba was used to estimate the length of stay in long-term care facilities and duration of home care services received. A daily cost of home care services and long-term care services was applied based on Ontario information from RAI-HC, at $26 and $148, respectively.

| Type of services               | Unit cost                        | Major assumptions                                                                 |
|-------------------------------|----------------------------------|-----------------------------------------------------------------------------------|
| Acute hospitalization         | RIW cost $5,399.04 per RIW unit (CIHI) | Quebec information was imputed based on other Canadian provinces; patient-level costing |
| Physician visit fees          | $79.20: admission; $55.45: 2nd, 3rd, and last day; $29.20: other days | Added to RIW cost                                                                |
| Surgical procedure fees       | Range from $76 immobilization of hip to $2,551 for fixation or reduction for vertebral fracture (average $1,352) (OSBPS) | Added to RIW cost                                                                |
| Diagnostic tests              | Range from $33 for forearm X-ray to $117 for MRI of vertebral fracture (average of $75) (OSBPS) | Added to RIW cost                                                                |
| Rehabilitation care           | $15,449 (RIW cost) per admission inflated by physician visit fee (CIHI) | Number based on net transfers from acute care; length of stay and costing based on rehabilitation database; patient-level costing |
| Continuing care               | $420.12 (RIW cost) per admission inflated by physician visit fee (CIHI) | Number based on net transfers from acute care; length of stay and costing based on continuing database; patient-level costing |
| Home care                     | $26 per day (RAI-HC Minimum Data Set) | Ontario data on number of recipients extrapolated to Canada; length of stay based on Manitoba data and unit costs from Ontario |
| Long-term care                | $147.77 per day (Ontario provincial budget) | Number based on net transfers from acute care; length of stay based on Manitoba data and unit costs from Ontario |

RIW = resource intensity weight; CIHI = Canadian Institute for Health Information; OSBPS = Ontario Schedule of Benefit for Physician Services; RAI-HC = Resident Assessment Instrument for Home Care.
Outpatient physician visits related to the treatment of osteoporosis in Canada was derived from the IMS Health Canada(23) Canadian Disease and Therapeutic Index survey. Based on a representative sample of 652 office-based physicians stratified by region and specialty, this survey is designed to provide information about disease and treatment patterns of physicians in Canada. In this survey, each physician reports each quarter on all patient contacts for a period of two consecutive days. Physician visits were costed using data from the Ontario Schedule of Benefits for Physician Services.(32) Costs of osteoporosis prescriptions (eg, alendronate, etidronate, risendronate, zoledronic acid, teriparatide, and calcitonin) were obtained from Brogan, Inc. (24) Since the physician and drug data were not gender-specific, the proportion of visits and medication utilization attributable to male patients was derived from Manitoba data—the only database with this information available—and extrapolated to all the other Canadian provinces.

Estimation of indirect costs

Productivity costs due to time loss for both patients and caregivers were calculated using a two-step approach. For men aged 50 to 59 years and 60 to 69 years, the number of days spent in acute care, rehabilitation, and continuing care following an osteoporosis-related fracture was estimated using information from CIHI databases whereas the number of days spent receiving long-term care and home care services was estimated based on Manitoba data. Productivity loss costs were then estimated by multiplying the total number of days “off” to the Canadian labor force participation rate (ie, 77% in men aged 50 to 59 years and 43% in men aged 60 to 69 years were working(26) and the average Canadian daily wage ($24.12 per hour × 8 hours).(27) Men aged 70 years and over were assumed to be unemployed.

Time devoted to informal caregiving by patients’ family members or friends also represents forgone productivity loss and was therefore evaluated in this study. Using information from DAD, CaMos,(25) and Statistics Canada,(26,27) caregiver wage loss was calculated by multiplying the number of osteoporosis fracture-related days spent in acute and non-acute care facilities by the proportion of male patients using caregivers (47.2%), times the number of days of care (37 days), times the proportion of caregivers being employed (43.2%), and times the average daily wage ($24.12 per hour × 8 hours).

Sensitivity analyses

Three major assumptions were tested in sensitivity analyses. Admissions with a most responsible diagnosis of osteoporosis but without a secondary code of fracture or a fracture-related intervention were excluded from our base case analysis as it was unknown if these admissions were truly due to osteoporosis or if they were the results of a miss-codification. A sensitivity analysis was therefore conducted by including the costs related to these hospitalizations to the base case estimate. Second, when estimating the costs incurred from men with fractures residing in long-term care facilities, we excluded those living on a yearly basis in long-term care facilities due to osteoporosis. An economic model developed for the Ontario Ministry of Health and Long Term Care’s Medical Advisory Secretariat assumed in its calculations that 17% of Canadian men over the age of 65 were residents in long-term care facilities following an osteoporotic fracture.(33) A sensitivity analysis was therefore performed by assuming that a similar proportion of men were living in long-term care facilities due to osteoporosis. Thirdly, although the base case analysis assumed that 56% of all forearm, humerus, other, and multiple fractures were attributable to osteoporosis, a sensitivity analysis was conducted by assuming that all these fractures were osteoporosis-related (ie, using 100% attribution rate). Finally, since emergency visits and same day surgeries, and medication usage were extrapolated from provincial data, a sensitivity analysis around their associated costs was conducted to evaluate the impact of using provincial data for the extrapolations. Due to the lack of specific data, these calculations used the variation observed between Canadian provinces in the rate of hospitalizations for hip fractures in men (ranging from 0.81 to 1.17 with reference to the national average at 1.0).(34) Therefore the costs of emergency visits and same day surgeries were decreased by 19% and increased by 17%.

Results

Acute care costs

The number of acute hospital admissions attributable to osteoporosis-related fractures among Canadian men over the age of 50 years was estimated at 16,032 for FY 2007/2008. These hospitalizations resulted in $225,783 hospitalized days. Table 3 presents the details by age group and fracture site. As shown in Table 3, more than one-half of the hospitalizations were due to hip fractures and one-half of the hip fractures occurred in men aged 80 years and older. Hip fractures accounted for 57.7% of all the hospital stays. Multiple-site fractures were the most expensive fractures, costing an average $25,774 per hospitalization, followed by hip fractures ($20,750), vertebral fractures ($15,013), humerus fractures ($13,943), other-site fractures ($12,846), and forearm fractures ($8,607). In addition to hospitalizations, osteoporosis-related fractures in Canadian men resulted in 32,627 emergency room visits and 787 same day surgeries. While almost one-half of all emergency room visits were due to hip fractures (23%) and forearm fractures (21%), the majority of same day surgeries were related to forearm fractures (68%). Based on these numbers, the acute care costs associated with osteoporosis-related fractures in Canadian men were estimated at $340 million, of which hospitalizations represented 86% of all acute care costs. As shown in Fig. 1, presenting the details of the acute care costs by fracture type, hip fracture alone accounted for 54% of all acute care expenditures.

Non-acute care costs

Prior to being hospitalized for osteoporosis-related fracture, the majority of men were living at home (66%) or were transferred from an acute care setting (21%) (eg, transfer from emergency room or a day clinic in the hospital). Nine percent were residents of long-term care facilities prior to the hospitalization and 2% came from chronic care or other types of facilities. In contrast, 44% of men were discharged home after the hospitalization, 20% to an acute care facility, 11% to long-term care, 10% to
rehabilitation, 9% to home care, 6% to chronic care, and 1% to other types of facilities. Differences in transfer destinations were observed between types of fractures with 28.0% of hip fractures and 46.8% of multiple-site fractures being discharged back home. In comparison, 70% of men with all other types of fractures were discharged home. After excluding those already living in these facilities, 3,814 men were transferred to rehabilitation, continuing care, long-term care, and formal home care following osteoporotic fractures. Table 4 shows the number and average length of stay (LOS) of these net transfers (n = 3,814) by fracture type and non-acute care facility. Overall, 56% of all net transfers to non-acute care facilities were due to hip fractures.

The costs associated with these net transfers to non-acute care facilities were estimated to be $86 million when only net transfers were considered in the calculation. Figure 2 shows the details by fracture type. Almost two-thirds (64%) of these days “off” were related to home care services and 23.7% were due to hospital stays. After applying the Canadian labor force participation rate, the estimated cost due to lost productivity was $28 million. Second, the time engaged in informal caregiving for Canadian men (at all ages) sustaining osteoporotic fractures resulted in $54 million as productivity loss. Overall indirect costs were estimated at $82 million.

In the base case analysis, the total societal economic burden for treating and rehabilitating osteoporotic fractures among Canadian men aged ≥50 years was $570 million. Direct health care expenditure at $488 million accounted for 85.6% of the total costs. Figure 3 illustrates the distribution of the direct medical expenditures associated with the treatment of male osteoporosis. Approximately 70% of medical costs were spent on acute care. Table 5 presents the base case results as well as the results of the sensitivity analyses by cost category. Taking into account the hospital admissions with an osteoporosis diagnosis but without a fracture or relevant intervention code increased the total costs from $570 million to $575 million. Assuming that 17% of Canadian men over the age of 65 years were living in long-term care facilities due to an osteoporosis-related fracture, the costs attributed to long-term care increased from $6 million to $346 million. In this scenario the total cost attributable to osteoporosis in men was calculated at $910 million (versus $570 million in the base case scenario). When it was assumed that 100% of forearm, humerus, other, and multiple fractures were attributable to osteoporosis (versus 56% in the base case scenario), the costs increased from $570 million to $614 million. The analyses conducted to address the uncertainty associated with extrapolating emergency room visits and same day surgeries to Canada based on Ontario data indicated that the total cost estimates would change from $570 million to $561 million (lower estimate) and $578 million (higher estimate).

### Table 3. Estimated Number of Hospital Admissions and Length of Stay Attributable to Male Osteoporotic Fractures per Age Groups and Fracture Types

| Fracture site | Age 50–59 years | | Age 60–69 years | | Age 70–79 years | | Age 80+ years |
|---------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Average & LOS | Average & LOS | Average & LOS | Average & LOS | Average & LOS | Average & LOS |
| **n** | **LOS** | **n** | **LOS** | **n** | **LOS** | **n** | **LOS** | **Total admissions, n** | **Total LOS** |
| Hip           | 654 | 11 | 1,115 | 14 | 2,387 | 16 | 4059 | 17 | 8,215 | 130,375 |
| Vertebral     | 222 | 12 | 172 | 11 | 202 | 15 | 262 | 16 | 858 | 11,630 |
| Forearm       | 496 | 3 | 270 | 4 | 167 | 7 | 92 | 6 | 1,025 | 4159 |
| Humerus       | 127 | 9 | 131 | 9 | 111 | 19 | 130 | 16 | 499 | 6388 |
| Other sites   | 1192 | 6 | 896 | 9 | 789 | 13 | 820 | 17 | 3,697 | 39,024 |
| Multiple sites| 543 | 13 | 366 | 17 | 379 | 23 | 450 | 27 | 1,738 | 34,208 |
| Total         | 3234 | 9 | 2,950 | 11 | 4,035 | 15 | 5813 | 16 | 16,032 | 225,783 |

1 LOS = length of stay, days.

Fig. 1. Acute care expenditure related to male osteoporotic fractures.
representing a departure of less than 2% from the base-case cost estimate.

**Discussion**

This prevalence-based burden of illness study used several nationally representative sources of utilization and cost data to comprehensively estimate the direct and indirect costs attributable to osteoporosis in Canadian men aged 50 years and older in FY 2007/2008. Gaps in national data were filled with provincial and community data allowing us to provide a detailed picture of the burden of osteoporosis in men. Our findings indicate that male osteoporosis and osteoporotic fractures represent a substantial economic burden on the Canadian health care system and the society.

In FY 2007/2008, the total medical costs on male osteoporosis were estimated to be $488 million or 0.3% of Canadian health care expenditures (year 2008). The observed patterns of health service utilization were generally consistent with previous osteoporosis BOI studies in Canada. Acute care utilization represented the biggest cost driver, accounting for approximately 70% of all medical costs for male osteoporosis. Initial hospitalizations comprised the largest single component (60%) of total health expenditure. Hip fractures were the most prevalent fractures in men and accounted for the majority of the acute and non-acute care costs. Despite the outstanding burden of hip fracture, other types of osteoporotic fracture assumed greater importance among younger Canadian men (aged 50 to 59 years). This was also found in the recent Canadian study using data from Manitoba (population 1.2 million) to compare the 1-year healthcare costs for the year pre- and postfracture. At a population level, the median incremental healthcare costs associated with fractures in men residing in Manitoba were calculated at $108 million over a 10-year period, or an average of $10.8 million per year. When these results were extrapolated to the population of Canada (33.5 million habitants), the median incremental healthcare costs associated with new fractures in Canada would be $300 million. In comparison, we reported the mean healthcare costs of osteoporosis in Canada at $490 million. However, key differences in methods between our study and the study conducted in Manitoba (eg, respectively, Canadian data versus extrapolation

| Fracture site    | Rehabilitation | Continuing care | Long-term care | Home care | Total transfers, n | Total LOS |
|------------------|----------------|----------------|---------------|-----------|-------------------|-----------|
| Hip              | 1116           | 31             | 438           | 12        | 177               | 2136      |
| Vertebral        | 57             | 25             | 31            | 19        | 164               | 233       |
| Forearm          | 8              | 26             | 7             | 9         | 255               | 84        |
| Humerus          | 23             | 12             | 24            | 33        | 221               | 124       |
| Other sites      | 224            | 25             | 124           | 82        | 192               | 763       |
| Multiple sites   | 202            | 13             | 94            | 62        | 188               | 484       |
| Total            | 1629           | 22             | 717           | 218       | 200               | 3814      |

Number of net transfers is the net number of patients transferred from hospital to rehabilitation, continuing care, long-term care, and home care, after excluding those already living in these non-acute care facilities prior to hospitalization.

LOS = length of stay, days.

**Table 4.** Estimated Number of Net Transfers to Non-Acute Care Facilities and LOS Attributable to Male Osteoporotic Fractures per Care Facility and Fracture Types
from Manitoba, mean versus median costs, prevalence versus incidence-based burden of illness study, cost of osteoporosis versus cost of fracture) limit the comparability of these results. Without having access to patient-level data, we were not able to compute median costs to better compare our results with the Manitoba study. Although median costs are sometimes used in the presence of skewed cost data, only the arithmetic mean (average cost of treating all patients) is relevant for healthcare or policy decisions.\(^{36}\) Finally, the data was extrapolated from Manitoba to Canada for comparison purposes, which brings additional uncertainty when comparing the two estimates.

It is also very difficult to compare our results with previous BOI studies of osteoporosis in males conducted in other countries\(^ {8-13}\) due to differences in populations, methods (eg, definition of osteoporosis-related fractures, types of costs included in calculations) or healthcare systems. However, our results showing that acute care costs were the main medical cost driver (ie, 70% of direct medical costs) were consistent with U.S. findings (66%)\(^ {13}\) but higher than what was observed in a French study (49%).\(^ {10}\) Of importance, very few studies evaluated non-acute care costs\(^ {8,10,13}\) and only one study calculated indirect costs (no male-specific information could be obtained from the report)\(^ {8}\) However, as shown in our study, non-acute care and indirect costs together accounted for approximately 26% of total cost of male osteoporosis. These important cost components should not be neglected in future research.

Beyond the large healthcare costs, osteoporosis also consumed substantial human capital resources of patients and their families. In the present study, we also included the indirect costs associated with informal caregiving, which is often neglected in burden of illness studies.\(^ {57}\) The total indirect cost associated with lost productivity of affected patients and caregivers was valued at $82 million. Although our indirect cost estimates were based on Canadian data (eg, CaMos for the number of days of caregiving and Statistics Canada for participation rates), the analyses did not differentiate between full time and part time employees. As 15% of all Canadians over the age of 65 years are working part-time, we may have overestimated the indirect costs associated with loss of wages. Assuming that part-time employees do not incur any wage losses, the indirect costs would change from $82 million to $70 million. We may have overestimated the indirect costs associated with loss of wages by $12 million or less than 2% of the total cost. We also included in the calculation of indirect costs due to caregiver time losses from unpaid activities, which may explain why loss of productivity for the caregivers’ time was almost double the estimate of the fractured patients. It should be noted that our indirect cost estimates did not consider costs resulting from premature mortality while it has been shown that the mortality rate within the immediate post-fracture period is three times higher in men compared to women.\(^ {1,5}\) As such, the indirect costs estimates are likely to be an underestimate of the true indirect costs associated with osteoporosis. Although we estimated the cost of osteoporosis (OI) in men, the burden of OI in Canadian women is not documented. However, the direct medical cost of osteoporosis-related fractures in women has been reported to be two to four times that of men.\(^ {9,11,13,38}\) Based on this information, the direct medical cost associated with female osteoporosis fractures in Canada would range from $976 million to $2 billion. Unfortunately, indirect costs were rarely estimated for the burden of osteoporosis in literature and therefore we could not extrapolate our societal costs to women.

The economic burden estimates presented in this study were based on several representative national data sources and it is the first to consider the cost of osteoporosis in Canadian men. Nevertheless, as with any study using secondary data source, a few limitations should be noted. As we used diagnostic and intervention codes to identify fractures, our results may be affected by the possibility of miscoding. For this reason, the base case estimates did not include those hospitalizations with a primary diagnosis of osteoporosis but without any subsequent codes related to a fracture or its treatment. As suggested by the sensitivity analysis, this assumption had a minor impact on the result. However, it is possible that some fractures may have not been ascertained properly. For example, vertebral fractures are common among individuals with chronic obstructive pulmonary disease.\(^ {39,40}\) In the case of a hospitalization due to vertebral

---

**Table 5. Sensitivity Analysis Results**

| Type of cost                  | Base case cost ($) | Additional hospital admissions attributable to osteoporosis without a fracture code ($) | Inclusion of patients already in long-term care facilities prior to hospital admissions ($) | 100% Attribution to humerus, forearm, other and multiple fractures ($) |
|------------------------------|-------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| Direct medical costs         |                   |                                                                                       |                                                                                          |                                                                      |
| Acute care                   | 339,142,080       | 344,324,673                                                                            | Unchanged                                                                                | 369,437,784                                                          |
| Rehabilitation               | 30,331,813        | Unchanged                                                                              | Unchanged                                                                                | 31,799,796                                                          |
| Continuing care              | 43,763,871        | Unchanged                                                                              | Unchanged                                                                                | 45,954,262                                                          |
| Long-term care               | 6,244,271         | Unchanged                                                                              | 345,976,610                                                                              | 7,396,593                                                          |
| Home care                    | 6,044,974         | Unchanged                                                                              | Unchanged                                                                                | 6,653,352                                                          |
| Prescribed medications       | 29,470,455        | Unchanged                                                                              | Unchanged                                                                                | Unchanged                                                          |
| Outpatient physician services| 32,795,672        | Unchanged                                                                              | Unchanged                                                                                | 90,497,766                                                          |
| Indirect costs               | 82,347,583        | Unchanged                                                                              | Unchanged                                                                                | 614,005,681                                                         |
| Total cost                   | 570,140,719       | 575,323,312                                                                            | 909,873,058                                                                              | 614,005,681                                                         |
In conclusion, our study shows that osteoporosis is an important health problem in Canadian men. As the population of older men is going to increase substantially over the next decade, the burden of osteoporosis in men is likely to increase significantly. As such, implementation of preventive strategies to identify men at a high risk of fractures may alleviate some of this burden.

Disclosures

All authors state that they have no conflicts of interest.

Acknowledgments

We acknowledge the Manitoba Centre for Health Policy for use of data contained in the Population Health Research Data Repository (HIPC project #2009/2010-09). The results and conclusions are those of the authors and no official endorsement by the Manitoba Centre for Health Policy, Manitoba Health, or other data providers is intended or should be inferred. The study was sponsored by Amgen Canada, Inc.

Authors’ roles: Study design: JET, NG, RH, and RG. Data collection and analysis: JET, NG, and RH. Data interpretation: All authors. Drafting manuscript: JET and NG; Revising manuscript content: All authors. Approving final version of manuscript: All authors. JET takes responsibility of the integrity of the data analysis.

References

1. Cooper C, Campion G, Melton LJ III. Hip fractures in the elderly: a world-wide projection. Osteoporos Int. 1992;2(6):285–9.
2. Genant HK, Cooper C, Poor G, Reid I, Ehrlich G, Kanis J, Nordin BE, Barrett-Connor E, Black D, Bonjour JP, Dawson-Hughes B, Delmas PD, Dequeker J, Ragi Eis S, Gennari C, Johnell O, Johnston CC Jr, Lau EM, Liberman UA, Lindsay R, Martin TJ, Masri B, Mautalen CA, Meunier PJ, Khaltvea N, et al. Interim report and recommendations of the World Health Organization Task-Force for Osteoporosis. Osteoporos Int. 1999;10(4):259–64.
3. Gennari L, Bilezikian JP. Osteoporosis in men. Endocrinol Metab Clin North Am. 2007;36(2):399–419.
4. Papaioannou A, Morin S, Cheung AM, Atkinsion S, Brown JP, Feldman S, Hanley DA, Hodsmann A, Jamal SA, Kaiser SM, Kvemn B, Sminiosshi K, Leslie WD. Scientific Advisory Council of Osteoporosis Canada. 2010 clinical practice guidelines for the diagnosis and management of osteoporosis in Canada: summary. CMAJ. 2010;182(17):1864–73.
5. Thomas-John M, Codd MB, Manne S, Watts NB, Mongey AB. Risk factors for the development of osteoporosis and osteoporotic fractures among older men. J Rheumatol. 2009;36(9):1947–52.
6. Leslie WD, O’Donnell S, Jean S, Lagace C, Walsh P, Bancej C, Morin S, Hanley DA, Papaioannou A. Trends in hip fracture rates in Canada. JAMA. 2009;302(8):883–9.
7. Sanders KM, Nicholson GC, Ugoni AM, Pasco JA, Seemann E, Kotowicz MA. Health burden of hip and other fractures in Australia beyond 2000. Projections based on the Geelong Osteoporosis Study. Med J Aust. 1999;170(10):467–70.
8. Brecht JG, Schadlich PK. Burden of illness imposed by osteoporosis in Germany. Eur J Health Econ. 2000;1:26–32.
9. Johnell O, Kanis JA, Jonsson B, Oden A, Johansson H, De Laet C. The burden of hospitalised fractures in Sweden. Osteoporos Int. 2005;16(2):222–8.
10. Levy P, Levy E, Audran M, Cohen-Solal M, Fardellone P, Le Parc JM. The cost of osteoporosis in men: the French situation. Bone. 2002;30(4):631–6.
11. Lippuner K, Golder M, Greiner R. Epidemiology and direct medical costs of osteoporotic fractures in men and women in Switzerland. Osteoporos Int. 2005;16(Suppl 2):S18–7.
12. Maravic M, Le Bhihan C, Landais P, Fardellone P. Incidence and cost of osteoporotic fractures in France during 2001. A methodological analysis. Osteoporos Int. 2005;16(Suppl 2):S8.
13. Ray NF, Chan JK, Thamer M, Melton LJ. Medical expenditures for the treatment of osteoporotic fractures in the United States in 1995: report from the National Osteoporosis Foundation. J Bone Miner Res. 1997;12(1):24–26.
14. Leslie WD, Metge CJ, Azimae M, Lix LM, Finlayson GS, Morin SN, Caetano P. Direct costs of fractures in Canada and trends 1996-2006: A population-based cost-of-illness analysis. J Bone Miner Res. 2011 Oct; 26(10):2419–27.
15. Goeree R, O'Brien B, Pettitt D, Cuddy L, Ferraz M, Adachi JD. An assessment of the burden of illness due to osteoporosis in Canada. J Soc Obstet Gynaecol Can. 1996;18(Suppl July):15–25.
16. Fraser LA, Ioannidides G, Adachi JD, Pickard L, Kaiser SM, Prior J, Brown JP, Hanley DA, Olszynski WP, Anastassiades T, Jamal S, Josse R,戈尔茨曼 D, Papaiioannou A. Fragility fractures and the osteoporosis care gap in women: the Canadian Multicentre Osteoporosis Study. Osteoporos Int. 2011;22(3):789–96.
