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Construction and validation of a simplified fracture risk assessment tool for Canadian women and men: results from the CaMos and Manitoba cohorts

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Abstract

Summary—A procedure for creating a simplified version of fracture risk assessment tool (FRAX®) is described. Calibration, fracture prediction, and concordance were compared with the full FRAX tool using two large, complementary Canadian datasets.

Introduction—The Canadian Association of Radiologists and Osteoporosis Canada (CAROC) system for fracture risk assessment is based upon sex, age, bone mineral density (BMD), prior fragility fracture, and glucocorticoid use. CAROC does not require computer or web access, and categorizes 10-year major osteoporotic fracture risk as low (<10%), moderate (10–20%), or high (>20%).

Methods—Basal CAROC fracture risk tables (by age, sex, and femoral neck BMD) were constructed from Canadian FRAX probabilities for major osteoporotic fractures (adjusted for prevalent clinical risk factors). We assessed categorization and fracture prediction with the updated CAROC system in the CaMos and Manitoba BMD cohorts.

Results—The new CAROC system demonstrated high concordance with the Canadian FRAX tool for risk category in both the CaMos and Manitoba cohorts (89% and 88%). Ten-year fracture outcomes in CaMos and Manitoba BMD cohorts showed good discrimination and calibration for both CAROC (6.1–6.5% in low-risk, 13.5–14.6% in moderate-risk, and 22.3–29.1% in high-risk

individuals) and FRAX (6.1–6.6% in low-risk, 14.4–16.1% in moderate-risk, and 23.4–31.0% in high-risk individuals). Reclassification from the CAROC risk category to a different risk category under FRAX occurred in <5% for low-risk, 20–24% for moderate-risk, and 27–30% for high-risk individuals. Reclassified individuals had 10-year fracture outcomes that were still within or close to the original nominal-risk range..

Conclusion—The new CAROC system is well calibrated to the Canadian population and shows a high degree of concordance with the Canadian FRAX tool. The CAROC system provides s a simple alternative when it is not feasible to use the full Canadian FRAX tool.

Keywords

Bone mineral density; Canada; CAROC; Fracture risk prediction; FRAX; Osteoporosis

Introduction

In the absence of a defining fracture, the diagnosis of osteoporosis is based on the measurement of bone mineral density (BMD) by dual-energy X-ray absorptiometry (DXA). The World Health Organization has provided an operational definition of osteoporosis as a BMD that lies 2.5 standard deviations or more below the average mean value for young healthy women (T-score≤−2.5 standard deviations (SD)) based upon a standardized reference site (the femoral neck) and reference population (the NHANES III data for women aged 20–29 years) [1–3].

Although reduced bone mass is an important and easily quantifiable measurement, studies have shown that most fractures occur in individuals with a BMD T-score above the operational threshold [4–6]. Recognizing the limitations of BMD alone, a simple semi-quantitative approach for BMD reporting based upon 10-year major osteoporotic fracture risk prediction was developed in 2005 by the Canadian Association of Radiologists and Osteoporosis Canada (CAROC) [7]. The CAROC system integrates the independent effects of sex, age, BMD (originally based on minimum T-score) and two clinical risk factors (prior fragility fracture and prolonged glucocorticoid use). The original CAROC system used available 10-year fracture probability data from Sweden [8]. These two clinical risk factors (CRF) were supported by evidence that they were strong and consistent predictors of fracture risk; subsequent meta-analyses have confirmed their importance as BMD-independent risk factors [9–11]. The CAROC system has been very popular in Canada with primary care physicians and radiologists since it is intuitive and easily summarized on a pocket card.

The original CAROC system was found to overestimate fracture risk in Canadians [12, 13]. This was attributable to several factors: Sweden has among the highest fracture rates in the world; substitution of minimum T-score for femoral neck T-score gives systematically higher risk estimates; the published Swedish fracture probabilities were for an average individual and included some with the CAROC clinical risk factors which results in “double-counting”; and the published Swedish fracture probabilities were from almost 20 years ago and do not reflect secular decreases in hip fracture rates that have been observed in Canada [14].

Released in 2008, the WHO fracture risk assessment tool (FRAX®) allows for quantitative estimation of individual 10-year major osteoporotic and hip fracture probability [15]. In addition to age, sex, and (optionally) BMD, the following risk factors are considered: prior fragility fracture, body mass index (BMI), prior use of glucocorticoids, secondary osteoporosis, rheumatoid arthritis, a parental history of hip fracture, current cigarette smoking, and alcohol intake of 3 or more units/day. Analyses have confirmed that there is an improvement in fracture prediction in the use of BMD and CRFs together when compared with BMD alone or CRFs alone [16].

A Canadian FRAX tool has recently been developed and calibrated with Canadian hip fracture epidemiology (FRAX web version 3.1) [17]. Although FRAX provides a more complete description of clinical risk factors not included in the CAROC system, there is uncertainty over the incremental benefit of including additional weaker clinical risk factors [18]. Furthermore, using FRAX requires specialized software and/or access to the website. The FRAX software is still not widely available on BMD machines in Canada. The objective of the current study was to update the CAROC risk tables based upon the Canadian FRAX tool, thereby providing a simple alternative in primary care for individuals for do not have access to computer-based FRAX calculations. Classification and fracture prediction were evaluated in two complementary populations, namely the Canadian Multicentre Osteoporosis Study (CaMos) and the Manitoba Bone Density Program cohort. CaMos is a population-based study and therefore provides information on potential intervention rates for the general population. The Manitoba Bone Density Program cohort is a large clinical referral population and therefore provides information on implications for routine clinical practice.

Methods

CaMos cohort

CaMos is an ongoing, prospective cohort study of 9,423 community-dwelling, randomly selected women (6,539) and men (2,884), aged 25 years and older at baseline, living within 50 km of nine Canadian cities (St John’s, Halifax, Quebec City, Kingston, Toronto, Hamilton, Saskatoon, Calgary, and Vancouver) that began cohort recruitment in 1997–1998. CaMos objectives, methodology and sampling framework are described in detail elsewhere [19]. Briefly, data collection at baseline included an extensive interviewer administered questionnaire and a clinical assessment. The questionnaire included socio-demographic information, medical and fracture history, family history, dietary intake, physical activity, and tobacco smoking. Clinical assessments included height, weight, and BMD by DXA. Yearly fracture information are collected by phone interviews or interviews when the participant is due for an extensive follow-up (years 3 (40–60 years old), 5 and 10). All study participants gave written informed consent in accordance with the Helsinki declaration. Ethics approval was granted through McGill University and the appropriate ethics review boards for each participating center.

The present study included women and men aged 50 years and older at baseline with complete data on FRAX risk factors [20]. Weight and height were recorded at the time of the DXA examination. Prior history of osteoporotic fracture after age 50 was assessed from

questionnaire, and excluded fractures of the head, hands, ankle, or feet and those due to high trauma. Current smoking (cigarettes, cigars, or pipe) and number of daily alcohol servings were obtained from the CaMos questionnaire. Glucocorticoid use was defined as current and regular use of oral or intravenous glucocorticoids identified by drug codes. Since self-reported rheumatoid arthritis and osteoarthritis are often confused, we required that patients reporting rheumatoid arthritis also indicate treatment with one of the following drug codes: glucocorticoid, methotrexate, hydroxychloroquine, leflunomide, etanercept, or infliximab. All FRAX risk factors were based on baseline measures with the exception of parental hip fracture which was a composite; history of parental hip fracture was used for everyone with year 5 data, whereas history of any parental osteoporotic fracture was used from the baseline questionnaire for those without year 5 data.

Femoral neck BMD was measured by DXA using Hologic or Lunar DPX densitometers, depending on the CaMos regional center. A detailed description of BMD quality control is available elsewhere [21]. Briefly, longitudinal stability was monitored using a spine phantom, local to each center. Lunar data were converted into equivalent Hologic values by standard methods [22]. All densitometers were calibrated at the start of the study and once each year thereafter using a single European Spine Phantom to ensure site-to-site comparability. All measurements were re-analyzed centrally by the same three technicians.

Manitoba cohort

The study population for this historical cohort study consisted of all women and men in the Province of Manitoba, Canada, age 50 years or older at the time of baseline femoral neck DXA. Subjects were required to have medical coverage from Manitoba Health during the observation period ending March 2008 without other exclusions. For those with more than one eligible set of measurements, only the first record was included. The study was approved by the Research Ethics Board for the University of Manitoba and the Health Information Privacy Committee of Manitoba.

Fractures can be assessed in Manitoba through a combination of hospital discharge abstracts (diagnoses and procedures coded using the ICD-9-CM and ICD-10-CA systems) and physician billing claims (in-patient, out-patient, and office-based) [23]. Use of systemic glucocorticoids was obtained by linkage to the provincial Drug Program Information Network database with drugs classified according to the Anatomical Therapeutic Chemical system of the WHO [24]. The pharmacy database is accurate both for capture of drug dispensations as well as the prescription details [25]. Prolonged glucocorticoid use was defined as over 90 days dispensed in the year prior to DXA testing at a mean prednisone-equivalent dose of 7.5 mg per day or greater. Longitudinal health service records were assessed for the presence of hip, clinical vertebral, forearm, and humerus fracture codes (collectively designated as “osteoporotic”) before and after BMD testing that were not associated with trauma codes [26]. We required that hip fractures and forearm fractures be accompanied by a site-specific fracture reduction, fixation, or casting code which enhances the diagnostic and temporal specificity for an acute fracture. Prior fragility fracture was taken be a fracture prior to BMD testing based upon the previous definition. A diagnosis of rheumatoid arthritis testing was taken from physician office visits and/or hospitalizations

with a compatible ICD-9-CM/ICD-10-CA code in a 3-year period prior to BMD testing. Parental hip fracture information was only collected in the last 2 years (2005 and onwards) and was therefore missing for earlier cases. Proxies were used for smoking (chronic obstructive pulmonary disease (COPD) diagnosis) and high alcohol intake (alcohol or substance abuse diagnosis). Weight and height were recorded at the time of the DXA examination (prior to 2000, this was by self-report and starting in 2000 height was assessed with a wall-mounted stadiometer and weight was assessed without shoes using a standard floor scale).

Bone density testing with DXA has been available in Manitoba since 1990 and managed as an integrated program since 1997 using targeted case-finding and standard criteria as previously published [27, 28]. The program maintains a database of all DXA results which can be linked with other population-based computerized health databases through an anonymous personal identifier [29]. The DXA database has been previously described with completeness and accuracy in excess of 99%. DXA scans were performed and analyzed in accordance with manufacturer recommendations. Prior to 2000, DXA measurements were performed with a pencil-beam instrument (Lunar DPX, GE Lunar, Madison WI) and after this date a fan-beam instrument was used (Lunar Prodigy, GE Lunar, Madison WI). Instruments were cross-calibrated using anthropomorphic phantoms and 59 volunteers. No clinically significant differences were identified (femoral neck T-score differences <0.2). Therefore all analyses are based upon the unadjusted numerical results provided by the instrument. Densitometers showed stable long-term performance and satisfactory in vivo precision [30].

CAROC system

Under the original CAROC system [7], each subject was assigned a basal fracture risk category (low risk <10%, moderate risk 10–20%, and high risk >20%) based upon BMD, sex and age using 10-year fracture probability risk tables from Sweden [8]. The presence of prior fragility fractures and/or prolonged systemic glucocorticoid substantially elevates fracture risk. This was operationalized under the CAROC system by increasing the risk categorization to the next level: from low risk to moderate risk, or from moderate risk to high risk. When both factors were present (i.e., prior fragility fractures and prolonged systemic glucocorticoid use), the patient was considered to be at high fracture risk regardless of the BMD result.

To update the CAROC risk tables, we used the sex-specific major osteoporotic fracture probability tables for the Canadian FRAX tool calibrated by the WHO Coordinating Centre from 2005 national hip fracture epidemiology [17]. These risk tables give 10 year fracture probabilities according to BMD (femoral neck T-score from −4.0 to +1.0 in 0.5 SD increments) and age (from 50 to 90 in 5 year increments). The FRAX basal risk tables (i.e., without additional clinical risk factors) would slightly underestimate fracture risk under the CAROC system since there are additional FRAX risk factors (rheumatoid arthritis, parental history of hip fracture, current cigarette smoking, and alcohol intake of 3 or more units/day) that contribute to higher fracture risk. To adjust for the effect of these additional FRAX clinical risk factors which are not part of the CAROC formulation, we derived sex-and age-

specific factors from the Manitoba cohort that reflect their average effects. Firstly, the basal FRAX risk tables were bilinearly interpolated to derive intermediate ages (nearest year) and T-scores (0.1 SD steps), and a risk probability ($FRAX_{basal}$) was determined for every person in the Manitoba cohort. Secondly, that person's FRAX probability ($FRAX_{CAROC}$) was computed without prior fragility fracture or prolonged glucocorticoid use (i.e., both responses set to "no") but including all other FRAX risk factors as originally defined. The average ratio $FRAX_{CAROC}/FRAX_{basal}$ was computed for 5-year age groupings in men (range, 1.03 to 1.12) and women (range, 1.03 to 1.10), and reflects the additional effect of the non-CAROC risk factors on fracture probability. Finally, values in the FRAX basal risk tables (i.e., without additional clinical risk factors) were multiplied by the corresponding ratio. Sex-and age-specific cutoffs corresponding to fracture probabilities of 10% and 20% (the cutoffs that categorize individuals into low, moderate or high fracture risk under CAROC) were identified and defined the updated CAROC basal risk values (Table 1). Additional details are available on request from the authors.

For each individual in the CaMos and Manitoba cohorts, the CAROC risk category was then calculated based upon the category from the basal CAROC risk table with a risk category increase for each of the two CAROC clinical risk factors (prior fragility fracture and prolonged glucocorticoid use). For comparison purposes, we also categorized major osteoporotic fracture probability from the full Canadian FRAX tool for all individuals in the CaMos and Manitoba cohorts using the same criteria (low <10%, moderate risk 10–20%, and high risk >20%).

Statistics

Descriptive statistics for demographic and baseline characteristics are presented as mean ± SD for continuous variables or count (percent) for categorical variables. The CAROC risk category was compared with the FRAX risk category computed for each individual from the Canadian FRAX model. Concordance in risk category designation overall and stratified by the number of CAROC clinical risk factors was computed by summing the diagonal elements and dividing by the number of subjects. Observed 10-year major osteoporotic fractures (hip, forearm, humerus, clinical spine) rates and risk reclassification were then studied in relation to the three CAROC categories according to the method of Janes et al. [31]. Ten-year estimates of osteoporotic fracture were derived using the Kaplan–Meier method with observations censored at end of follow-up or 10 years (whichever came sooner) and death treated as a competing hazard. Separate analyses were performed for both cohorts. Statistical analyses were performed with Statistica (version 7.0, StatSoft Inc, Tulsa, OK).

Results

The CaMos cohort included 6,697 subjects (4,778 women and 1,919 men) age 50 years old or greater. The Manitoba cohort included 39,603 subjects (36,730 women and 2,873 men). Baseline characteristics are summarized in Table 2. Differences between the two cohorts are consistent with expected clinical referral bias in the Manitoba cohort, particularly among men. Men included in the Manitoba cohort were on average 3 years older than CaMos men and had lower femoral neck T-scores, while women had similar age and femoral neck T-

score. CaMos women and men had a lower prevalence of prior fracture, parental hip fracture, rheumatoid arthritis and glucocorticoid use than the Manitoba cohort. Differences in the prevalence of smoking and high alcohol intake were relatively small and potentially related to the use of proxy measures (COPD and substance abuse diagnosis) in the Manitoba cohort.

The CAROC system demonstrated a high level of concordance with Canadian FRAX risk category in both cohorts with overall concordance of 89% in CaMos (Table 3) and 88% in the Manitoba cohort (Table 4). Concordance was highest in individuals without prior fragility fractures and without prolonged glucocorticoid use (92% and 93%), followed by those with both clinical risk factors (100% and 76%), and was lowest for those with a single clinical risk factor (61% and 74%). Reclassification of the CAROC low-risk category to a different risk category under the Canadian FRAX system (i.e., the proportion of the low-risk category in CAROC reclassified to moderate or high risk under FRAX) was less than 5% in both CaMos (Table 5) and the Manitoba cohort (Table 6). Reclassification of the CAROC moderate-risk category under FRAX (to low or high) was seen in 24.4% of the participants in CaMos and 19.5% in the Manitoba cohort. For the CAROC high-risk category, reclassification (to low or moderate) was seen in 29.9% and 27.0%, respectively. However, virtually all of the reclassification was to an adjacent risk category (only a single individual changed two categories, from high to low).

In a well-calibrated model, 10-year fracture risk would be expected to be below 10% for low-risk individuals, close to 15% for moderate-risk individuals, and above 20% for high-risk individuals. In Tables 5 and 6, 10-year fracture outcomes (Kaplan–Meier estimates) in both study cohorts showed good calibration for both CAROC (6.1–6.5% in low-risk, 13.5–14.6% in moderate-risk, and 22.3–29.1% in high-risk individuals) and Canadian FRAX (6.1–6.6% in low-risk, 14.4–16.1% in moderate-risk, and 23.4–31.0% in high-risk individuals). Both systems generated fracture rates that were well within the nominal-risk ranges for both cohorts. Furthermore, reclassified individuals had fracture outcomes that were still within or close to the original nominal-risk ranges. For example, when the CAROC moderate-risk category was reclassified under Canadian FRAX, the fracture outcomes at 10 years were 9.0–9.2% in those reclassified to low risk and 14.3–19.9% in those reclassified to high risk. Conversely, when the moderate-risk category under Canadian FRAX was reclassified under CAROC, the 10 year fracture outcomes were 10.9–14.3% in those reclassified to low risk and 18.4–21.4% in those reclassified to high risk.

The study populations were further stratified according to the presence or absence of FRAX clinical risk factors that do not contribute to CAROC (i.e., parental history of hip fracture, smoking (or COPD), excess alcohol intake [or substance abuse diagnosis], rheumatoid arthritis). One or more additional FRAX risk factors were identified in 23% of the CaMos cohort and 17% of the Manitoba cohort. When there were no additional FRAX risk factors, 90% concordance was seen between the CAROC and Canadian FRAX risk categories in both the CaMos and Manitoba cohorts. Slightly lower concordance was seen when there were additional FRAX risk factors: 81% in the CaMos and 77% in the Manitoba cohorts. Observed 10 year fracture outcomes showed a stepwise increase according to the CAROC risk category (Fig. 1). In the Manitoba cohort, the subgroup categorized as low risk under

CAROC but with additional FRAX risk factors was at higher risk than those without additional FRAX risk factors but no difference was seen for the corresponding CaMos subgroups. For subgroups categorized as moderate or high risk under CAROC, the observed 10-year fracture outcomes stratified according to presence or absence of additional FRAX risk factors were similar.

Discussion

The updated CAROC risk system shows good calibration and discrimination in two independent Canadian cohorts, one a population-based cohort and the other representative of patients seen in clinical practice. Moreover, these risk categories agreed closely with risk categories derived from the Canadian FRAX tool. No major benefit in using the full Canadian FRAX system over CAROC was evident, and reclassified individuals had 10-year fracture outcomes that were still within or close to the original nominal-risk range. Therefore, CAROC provides a simple tool for assessing fracture risk in primary care. FRAX is based upon a more complete set of clinical risk factors, and offers greater versatility since it allows for risk assessment in the absence of a BMD measurement and is more quantitatively accurate for those patients with one of more of the risk factors that contribute to FRAX but not to CAROC (i.e., parental history of hip fracture, smoking, excess alcohol intake, rheumatoid arthritis). The two-risk assessment tools are therefore seen as complementary versions of the same system, and the choice of using Canadian FRAX or CAROC is largely a matter of personal preference and convenience.

In the absence of a Canadian FRAX tool, Swedish fracture data have previously been used for estimating fracture risk in Canada [32]. This is not optimal because of possible miscalibration due to known international variation in fracture risk and the fact that Sweden has among the highest fracture rates in the world [33, 34]. We confirmed that the derivation of the original CAROC risk tables from Swedish data resulted in thresholds which overestimated fracture risk among Canadians [7]. The risk cutoffs for men and women from the updated CAROC system are substantially lower than the original CAROC cutoffs for many sex and age combinations (notably women 50–75 years and men 70–85 years). For example, at age 65 a women without other risk factors would need a femoral neck T-score of −1.9 or lower to be at moderate risk and −3.5 or lower to be at high risk. This compares with the original CAROC cutoffs −1.0 and −2.7. The change is attributable to the use of 2005 Canadian fracture data for construction of the updated CAROC risk tables, whereas the original CAROC tables used published Swedish fracture probabilities [8]. The published Swedish fracture probabilities were from almost 20 years ago and do not reflect secular decreases in hip fracture rates that have been observed in Canada [14].

FRAX was created as a quantitative fracture risk assessment tool and is available free of charge on the internet at www.shef.ac.uk/FRAX and more recently as an iPhone application [20]. It was derived from nine prospective cohorts (which included 5-year data from CaMos) and was validated in 11 different population-based prospective cohorts from Europe, the USA, Australia, and Japan [16]. Recent work has validated calibration and discrimination of the Canadian FRAX tool using 10-year CaMos data and the Manitoba Bone Density Program [35, 36]. Our study does not indicate that the additional clinical risk factors used in

FRAX are unimportant, as the derivation meta-analyses and a recent report work in the Manitoba cohort show independent contributions to fracture risk prediction in individuals with those risk factors [15, 16, 36]. However, the additional benefit is relatively small and therefore not readily apparent when averaged across groups of individuals.

Strengths of this investigation include the use of two independent Canadian cohorts. Similar findings in both population-based and clinical referral populations increase confidence in the robustness of the findings. These two cohorts are complementary and used different data sources, slightly different risk factor definitions and methods for fracture ascertainment. Hence, limitations of one population may not apply to the other population. In the Manitoba cohort, proxies were used for two of the risk factors utilized to generate the FRAX probabilities: COPD diagnosis instead of smoking, alcohol or substance abuse diagnosis for high alcohol intake (more than 2 units of alcohol per day). As a result, patients with these risk factors in the Manitoba cohort are likely to have greater exposure than the CaMos participants with these risk factors. In the CaMos cohort, a definition was used for rheumatoid arthritis that would only include those on disease-modifying treatment. The parental hip fracture variable was a composite construction in the CaMos cohort and partially missing in the Manitoba cohort. Although the current analysis was particular to the Canadian FRAX tool and population, the procedure outlined for creating a simplified risk assessment system should be generalizable to other FRAX tools.

In conclusion, the updated CAROC system is well calibrated in terms of osteoporotic fracture outcomes and shows a high overall degree of concordance with the full FRAX system. The full Canadian FRAX system provided little additional fracture risk stratification compared with the simplified CAROC system. However, FRAX is based upon a more complete assessment of risk factors (including some associated with secondary osteoporosis) and is therefore preferred to the CAROC system for fracture risk assessment. The simplified CAROC system is an acceptable alternative in Canada where it is not possible to adopt the full Canadian FRAX system.

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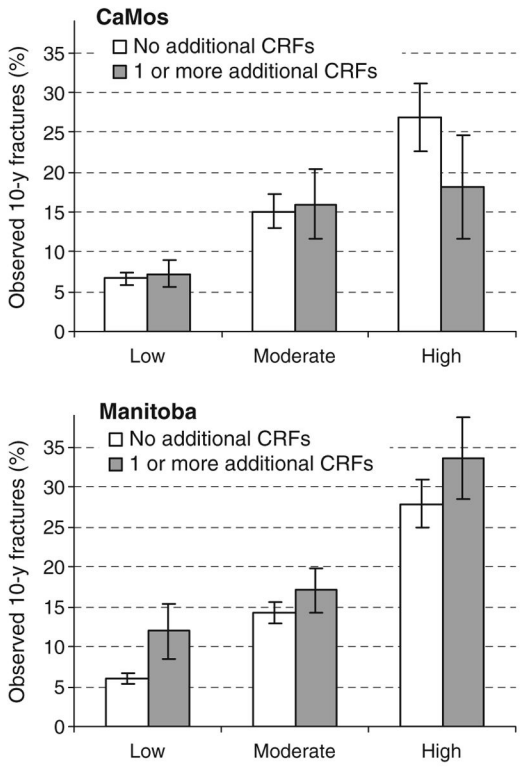

Fig. 1.

Observed 10-year major osteoporotic fracture outcomes by CAROC risk category according to the absence (*white bar*) or presence (*gray bar*) of one or more additional FRAX clinical risk factors (CRFs). 95% CI bars are shown

Table 1

CAROC basal risk tables for women and men based upon femoral neck T-scores (female white NHANES III). Missing values indicate no suitable cutoff

Age (years)	Women		Men	
	10% cutoff[a]	20% cutoff[a]	10% cutoff[a]	20% cutoff[a]
50	−3.4	–	−3.2	–
55	−2.9	–	−2.9	−3.9
60	−2.3	−3.7	−2.5	−3.7
65	−1.9	−3.5	−2.4	−3.7
70	−1.7	−3.2	−2.3	−3.7
75	−1.2	−2.9	−2.3	−3.8
80	−0.5	−2.6	−2.1	−3.8
85	0.1	−2.2	−2.0	–
90	−0.1	−2.5	−2.9	–

[a]A value above the 10% cutoff indicates low risk; a value below the 20% cutoff indicates high risk; and intermediate values indicate moderate risk

Table 2

Baseline characteristics of the CaMos and Manitoba cohorts

	CaMos		Manitoba	
	Women (*N*=4,778)	**Men (*N*=1,919)**	**Women (*N*=36,730)**	**Men (*N*=2,873)**
Age	65.8±8.8	65.3±9.1	65.7±9.8	68.2±10.1
BMI	27.1±4.9	27.3±3.8	26.8±5.2	27.1±4.4
Prior fragility fracture	11.3%	4.9%	13.6%	15.0%
Parental hip fracture	8.3%	5.8%	13.2%[a]	10.6%[a]
Rheumatoid arthritis	0.9%	0.3%	3.6%	7.6%
Current/recent glucocorticoid use	1.4%	1.4%	4.2%	22.1%
Current smoking (or proxy)	13.3%	17.8%	8.0%	18.1%
Alcohol use, ≥3 units (or proxy)	0.9%	6.8%	2.4%	4.2%
Femoral neck T-score (white female)	−1.5±1.1	−0.5±1.2	−1.5±1.0	−1.2±1.1

Date are mean ± SD or percent

[a]For 2005–2007 (*N*=8439 women, 814 men).

Table 3

CaMos concordance in risk stratification for Canadian FRAX versus CAROC for 10 year major osteoporotic fracture

CAROC	Canadian FRAX			
	Low (<10%)	Moderate (10–20%)	High (>20%)	Total
All subjects				
Low (<10%)	4,295 (64)	191 (3)	0 (0)	4,486 (67)
Moderate (10–20%)	312 (5)	1,169 (17)	65 (1)	1,546 (23)
High (>20%)	0 (0)	199 (3)	466 (7)	665 (10)
Total	4,607 (69)	1,559 (23)	531 (8)	6,697 (100)
Concordance				5,930 (89)
No-risk factors				
Low (<10%)	4,295 (72)	191 (3)	0 (0)	4,486 (75)
Moderate (10–20%)	205 (3)	981 (16)	47 (1)	1,233 (21)
High (>20%)	0 (0)	55 (1)	213 (4)	268 (4)
Total	4,500 (75)	1,227 (20)	260 (4)	5,987 (100)
Concordance				5,489 (92)
One-risk factors				
Low (<10%)	0 (0)	0 (0)	0 (0)	0 (0)
Moderate (10–20%)	107 (16)	188 (27)	18 (3)	313 (45)
High (>20%)	0 (0)	143 (21)	234 (34)	377 (55)
Total	107 (16)	331 (48)	252 (37)	690 (100)
Concordance				422 (61)
Two-risk factors				
Low (<10%)	0 (0)	0 (0)	0 (0)	0 (0)
Moderate (10–20%)	0 (0)	0 (0)	0 (0)	0 (0)
High (>20%)	0 (0)	0 (0)	20 (100)	20 (100)
Total	0 (0)	0 (0)	20 (100)	20 (100)
Concordance				20 (100)

Results are stratified by the number of additional clinical risk factors (prior fragility fracture and prolonged glucocorticoid use)

Table 4

Manitoba concordance in risk stratification for Canadian FRAX versus CAROC for 10-year major osteoporotic fracture

CAROC	Canadian FRAX			
	Low (<10%)	Moderate (10–20%)	High (>20%)	Total
All subjects				
Low (<10%)	20,857 (53)	889 (2)	0 (0)	21,746 (55)
Moderate (10–20%)	2,028 (30)	9,894 (25)	364 (1)	12,286 (31)
High (>20%)	5 (0)	1,497 (4)	4,069 (10)	5,571 (14)
Total	22,890 (342)	12,280 (31)	4,433 (11)	39,603 (100)
Concordance				34,820 (88)
No-risk factors				
Low (<10%)	20,857 (65)	889 (3)	0 (0)	21,746 (67)
Moderate (10–20%)	704 (12)	7,684 (24)	306 (1)	8,694 (27)
High (>20%)	0 (0)	350 (1)	1,464 (5)	1,814 (6)
Total	21,561 (360)	8,923 (28)	1,770 (5)	32,254 (100)
Concordance				30,005 (93)
One-risk factors				
Low (<10%)	0 (0)	0 (0)	0 (0)	0 (0)
Moderate (10–20%)	1,325 (19)	2,927 (41)	170 (2)	4,422 (62)
High (>20%)	0 (0)	375 (5)	2,310 (33)	2,685 (38)
Total	1,325 (19)	3,302 (46)	2,480 (35)	7,107 (100)
Concordance				5,237 (74)
Two-risk factors				
Low (<10%)	0 (0)	0 (0)	4 (2)	4 (2)
Moderate (10–20%)	0 (0)	0 (0)	55 (23)	55 (23)
High (>20%)	0 (0)	0 (0)	183 (76)	183 (76)
Total	0 (0)	0 (0)	242 (100)	242 (100)
Concordance				183 (76)

Results are stratified by the number of additional clinical risk factors (prior fragility fracture and prolonged glucocorticoid use)

Table 5

CaMos risk reclassification for Canadian FRAX versus CAROC for 10-year major osteoporotic fracture

CAROC	Canadian FRAX			
	Total	**Low (<10%)**	**Moderate (10–20%)**	**High (>20%)**
Low (<10%)				
N fracture	253	233	20	0
N total	4,486	4,295	191	0
Percent fracture	5.6%	5.4%	10.5%	N/A
Percent 10-year fracture outcomes[a]	6.1%	5.9%	10.9%	N/A
Total reclassified	4.3%	–	4.3%	0.0%
Moderate (10–20%)				
N fracture	192	26	154	12
N total	1,546	312	1,169	65
Percent fracture	12.4%	8.3%	13.2%	18.5%
Percent 10-year fracture outcomes[a]	13.5%	9.2%	14.3%	19.9%
Total reclassified	24.4%	20.2%	–	4.2%
High (>20%)				
N fracture	136	0	34	102
N total	665	0	199	466
Percent fracture	20.5%	N/A	17.1%	21.9%
Percent 10-year fracture outcomes[a]	22.3%	N/A	18.4%	24.0%
Total reclassified	29.9%	0.0%	29.9%	–
Total				
N fracture	581	259	208	114
N total	6,697	4,607	1,559	531
Percent fracture	8.7%	5.6%	13.3%	21.5%
Percent 10-year fracture outcomes[a]	9.3%	6.1%	14.4%	23.4%

[a]Kaplan–Meier estimate

Table 6

Manitoba risk reclassification for Canadian FRAX versus CAROC for 10-year major osteoporotic fracture

CAROC	Canadian FRAX			
	Total	**Low (<10%)**	**Moderate (10–20%)**	**High (>20%)**
Low (<10%)				
N fracture	21,746	20,857	889	0
N total	731	690	41	0
Percent 10-year fracture outcomes[a]	6.5%	6.3%	14.3%	N/A
Total reclassified	4.1%	–	4.1%	0.0%
Moderate (10–20%)				
N fracture	12,286	2,028	9,894	364
N total	937	106	807	24
Percent 10-year fracture outcomes[a]	14.6%	9.0%	15.5%	14.3%
Total reclassified	19.5%	16.5%	–	3.0%
High (>20%)				
N fracture	5,571	5	1,497	4,069
N total	875	1	157	717
Percent 10-year fracture outcomes[a]	29.1%	N/A	21.4%	31.9%
Total reclassified	27.0%	0.1%	26.9%	–
Total				
N fracture	39,603	22,890	12,280	4,433
N total	2,543	797	1,005	741
Percent 10-year fracture outcomes[a]	12.0%	6.6%	16.1%	31.0%

[a]Kaplan–Meier estimate