

Vertebral fracture risk and impact of database selection on identifying elderly Lebanese with osteoporosis

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Abstract

The International Osteoporosis Foundation recommends using a universal database i.e. the NHANES database for the diagnosis of osteoporosis. Population-based databases for *T*-score calculation are still debated in terms of clinical and public health relevance.

The current study aimed at estimating the prevalence of vertebral fractures in the Lebanese elderly, determining BMD–fracture relationship, and assessing the effect of database selection on osteoporosis prevalence and fracture risk assessment.

Apparently healthy subjects were randomly selected from the Greater Beirut area – one-third of the Lebanese population at large – using a multilevel cluster technique. Subjects with medical conditions likely to affect bone metabolism i.e. history of major chronic disease, intake of medications that affect bone metabolism were excluded. Presence of vertebral fracture was estimated by a semi-quantitative assessment. Bone density was measured by central DXA. Clinical risk factors included age, gender, height, weight, body mass index, smoking, exercise, falls, previous fragility fracture and family history of fragility fracture. Impact of database selection was assessed by:

- (1) Comparison of sensitivity and specificity for prevalent vertebral fractures of the *T*-score ≤ -2.5 threshold using local versus NHANES database.
- (2) Comparison of estimates for fracture risk (RR/SD decrease in BMD) using local versus NHANES database.

Prevalence of vertebral fractures was estimated at 19.9% [15.4–25.0] in women and at 12.0% [7.3–18.3] in men. Prevalence of osteoporosis by DXA using total hip was 33.0% [27.5–38.8] in women and 22.7% [16.2–30.2] in men. The NHANES database provided higher sensitivity for vertebral fracture than our population-specific database. RR of vertebral fracture per SD decrease in BMD remained unchanged across the two databases. In women, RR/SD were 1.61 [1.17–2.23] and 1.49 [1.14–1.95] in the NHANES and the local database, respectively, and in men 1.59 [0.94–2.72] and 1.43 [0.95–2.16].

In conclusion, our findings were in concordance with the IOF recommendations for the use of a universal database and could be used for the implementation of a unified fracture risk assessment paradigm along with the WHO initiative.

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Introduction

Osteoporosis is a major public health burden worldwide, and of steadily increasing magnitude as the size of the aging population continues to grow. It is projected that the problem may be even greater in developing countries [1–3].

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In the Middle East, epidemiologic data on osteoporosis are still limited [4–15]. In a recent population-based cross-sectional survey among the Lebanese population, estimated lifetime risk of peripheral fracture in women after the age of 50 was 13% [16]. Another prospective study estimated the projected annual number of osteoporotic hip fractures in Lebanon at 1500/year for about a population size of 4 million [17].

Although several studies from the Eastern Mediterranean have shown that bone mineral density (BMD) is slightly lower, 0.3–0.8 SD, depending on the skeletal site than that of western populations [18], the impact of such decrements on fracture risk is unclear. Indeed, very little if any is known about the relationship between BMD and fracture, in Eastern Mediterranean populations.

Two case–control studies conducted in Lebanese patients with hip fracture [19,20] revealed that mean BMD was similar to that reported in patients from western populations, although the fractures in the Lebanese occurred at a younger age, almost a decade earlier [21]. In spite of the recommendations by the International Osteoporosis Foundation to use a Universal standard database such as that of the NHANES, database selection for *T*-score calculation, and therefore for the diagnosis of osteoporosis based on BMD has been debated [22]. To date, there are no studies conducted in non-Western populations providing more insight into BMD–fracture risk relationship with respect to database selection.

Therefore we aimed at evaluating the prevalence of vertebral fractures in a representative sample of the Lebanese elderly, determining the BMD–fracture relationship, and assessing the effect of database selection on osteoporosis prevalence and fracture risk assessment.

Methods

Study group

Inclusion criteria

Lebanese residents from the Greater Beirut area, ages 65–84 years.

Exclusion criteria

Any medical condition likely to affect bone metabolism such as the history of major chronic disease, the intake of medications that affect bone metabolism, history of steroid intake for more than 6 months, treatment with bisphosphonates, selective estrogen receptor modulators, calcitonin or hormone replacement therapy for more than 1 year during the previous 5 years. Also excluded were subjects with history of bed rest for more than 1 month within 6 months prior to the study, subjects with previous surgery on the spine or both hips, and those with history of radiotherapy or chemotherapy. Subjects with conditions technically interfering with DXA BMD assessment were also excluded i.e. previous surgery on the spine, hip, forearm, or an imaging contrast procedure within the past week. The study was approved by the Institutional Review Board of the American University of Beirut, and informed consent was obtained from all study participants.

Sample selection

Apparently healthy subjects were randomly selected from the Greater Beirut area using a multilevel cluster technique. Greater Beirut constitutes 33% of the Lebanese population at large (Ministry of Social Affairs and WHO, 1996). Greater Beirut was broken down into regions and sub-regions with households.

The households were chosen randomly from the maps and the subject/household who fits the age range was selected. If more than one subject per household did fit the study entry criteria (including age range), then the eldest was selected from that household as the probability of finding people in the eldest range of age was expected to be small.

Sample size

In the large National Health and Nutrition Examination Survey (NHANES) study in the United States, 380–400 subjects were studied for each decade [23,24]. Based on an anticipated a BMD difference of 0.05 g/cm² (1/2 SD) compared to the American database [18], a SD of 0.11 g/cm², the study would require 77 subjects/gender/decade (power of 80%, with a two-sided α of 0.05; Instat version 2.0, Prism, San Diego, CA). Because osteoporosis is more common in women we weighed the sample towards more women; that is, 100 women and 80 men, aged 65–74 years and the same for ages 75–84 years, for a total of 200 women and 160 men. However, based on an anticipated prevalence of vertebral fractures of 20% in women after age 65 years, the required sample size for women was 300, i.e., a total sample size of 460 subjects.

Data collection

Risk factors

Age, gender, height, weight, body mass index, smoking, exercise, falls, previous fragility fracture and family history of fragility fracture were assessed [25]. Age, height, weight, body mass index were measured as quantitative variables. Smoking, falls, previous fragility fracture, family history of fragility fracture were measured as binary variables and exercise was estimated with self reported level of activity over the past week on a scale from 0 to 4, where 0 corresponded to the highest level with participation in leisure physical activities and 4 to the lowest level with need of a third-person assistance for daily activities.

Vertebral fracture assessment

Presence of vertebral fracture was assessed by a semi-quantitative assessment as reported by Genant et al. [26]. X-rays were assessed in two radiology centers and concordance rate was measured using a random subsample of 30 X-ray films. The agreement between the two readers was 80.6% and κ coefficient was 0.63. The technique described by Genant remains a reference for radiographic assessment of vertebral fracture [27–29].

Bone density measurement

Bone density was measured using a Hologic 4500A (Hologic Waltham, MA) at the American University of Beirut Medical Center and a Hologic 4500W densitometer at Hotel-Dieu de France. The mean ((SD) for lumbar spine (L1–L4), femur (neck, total femur), forearm (distal, 1/3 proximal) and total body was calculated by decade/gender. The *T*-score for the lumbar spine and hip were calculated using the following formula: *T*-score=subject's BMD-peak mean BMD/SD of peak BMD.

Population-based *T*-scores and western-based *T*-scores were calculated using the above formula. Mean peak BMD for the Lebanese at the spine and total hip was derived from a population-based database [18].

For western-based *T*-scores, peak lumbar spine BMD as provided by the densitometer software was used, and peak BMD for the total hip was that provided by the NHANES study [24]. The following formula was used: total hip NHANES-based *T*-score=subject's BMD (on Hologic) $-0.942/0.122$ [24]. The men's western or Lebanese database was used to derive *T*-scores in men.

Quality assurance and cross-calibration of densitometers

The mean \pm SD for precision, expressed as the coefficient of variation (CV %) for 83 serial duplicate scans performed in vivo at the time of the study, were as follows: Lumbar spine=0.90 \pm 0.79%, Total hip=0.84 \pm 0.70%, Femoral neck=1.35 \pm 1.14%, Trochanter=1.08 \pm 0.84%, Forearm=1.02 \pm 0.72%.

Cross-calibration was performed by having a total of 30 women having their bone density measured at all skeletal sites, the same day at the two centers.

Linear regression analyses were performed to allow conversion from one device to another, using cross-calibration formulas that were consistent with those reported in the literature [30–33] and were as follows:

Spine:	BMD QDR 4500A=0.004+1.02*BMDQDR 4500W. ($R^2=0.95$)
Total hip:	BMD QDR 4500A=0.05+0.98*BMDQDR 4500W. ($R^2=0.97$)
Femoral neck:	BMD QDR 4500A=0.21+0.67*BMDQDR 4500W. ($R^2=0.94$)
Trochanter:	BMD QDR 4500A=0.03+0.96*BMDQDR 4500W. ($R^2=0.94$)
Forearm:	BMD QDR 4500A=0.01+0.98*BMDQDR 4500W. ($R^2=0.89$)

BMD data presented in this paper were those as if all subjects were measured on the Hologic 4500 A densitometer.

Analyses of the scans at the spine

The scans were reassessed independently by two ISCD certified physicians (AA, GE–HF), in order to exclude any artifact effect of degenerative changes on BMD measurements at the spine. A vertebral body was excluded if any of the following criteria suggested by the ISCD applied [34]: focal structural defect, unusual discrepancy (by more than one unit) in T -score between two adjacent vertebrae, lack of increase in BMC or bone area when proceeding caudally from L1 to L4. In case of inter-observer disagreement, the most conservative approach was adopted. The average value of the readable vertebrae was then calculated, and the values were converted to be as if all subjects were measured on the Hologic 4500 A densitometer. Individual T -scores were derived using the database provided by the manufacturer as follows: (Average BMD of the readable vertebrae – Peak BMD of the readable vertebrae)/SD. Scans with only one readable vertebra were not included in the analyses. When scans of the spine were assessed according to ISCD criteria, there was inter-reader disagreement in 71 cases (15%). The scans were judged unreadable in 50 women (16%) and 24 men (15%). The lumbar spine was assessable using all four vertebrae (L1 to L4) in 91 women (30%) and 57 men (36%).

Prevalence of osteoporosis by the WHO criteria

The proportion of subjects with osteoporosis or osteopenia using the WHO BMD T -score criterion, $T \leq -2.5$, was estimated for each gender/decade. Figures were estimated using both a population-specific and the NHANES database for total hip BMD.

Prevalence of radiographic vertebral fractures

Only moderate and severe vertebral fractures were considered in the analyses, mild fractures (Genant grade I) were not included [28].

Risk factors for vertebral fracture and osteoporosis

Clinical risk factors including age, height, weight, past history of fragility fracture, recurrent falls, and family history of fragility fracture have been studied. Adjusted odds ratios were estimated using logistic regression with two models one with vertebral fracture and another with osteoporosis defined as a total hip T -score ≤ -2.5 as the dependent variable.

Table 1
Characteristics of the study population

	All, N=432	Women, N=282	Men, N=150	P-value ^a
Age (years)	73.6±5	73.5±5	74.0±5	0.44
Weight (kg)	70.5±14	69.5±15	72.3±11	0.049
Height (cm)	154.8±9	150.6±6	163.0±7	<0.0001
BMI (kg/cm ²)	29.5±6	30.7±7	27.2±4	<0.0001
History of fracture (%)	29.5	28.4	31.5	0.492
Current smoking (%)	30.8	28.7	34.7	0.203
Time spent outdoors/day (h)	2.6±4	1.8±3	4.2±4	<0.0001

Values are mean±SD.

^a P-values for difference between men and women.

Table 2

Bone mineral density (BMD; g/cm³), T -scores derived from western- and population-based standards^a, and Z -scores derived from western-based standards, at the spine, hip and forearm by gender

	Women, N=282		Men, N=150		P value
	Mean	SD	Mean	SD	
Total hip BMD	0.730	0.126	0.848	0.133	<0.0001
FN BMD	0.614	0.090	0.669	0.096	<0.0001
Total hip T -score	−2.040	1.047	−1.725	1.019	0.0029
Total hip T -score using Lebanese peak	−1.197	1.256	−0.802	0.947	<0.0008
FN T -score	−2.815	0.898	−2.818	0.873	0.91
Total hip Z -score	−0.119	1.012	−0.548	1.012	<0.0001
FN Z -score	−0.295	0.858	−0.731	0.868	<0.0001
Spine BMD	0.769	0.144	0.887	0.162	<0.0001
Spine T -score	−2.471	1.303	−1.907	1.586	0.0002
Forearm BMD	0.512	0.084	0.663	0.089	<0.0001
Forearm T -score	−3.026	1.397	−2.910	1.683	0.49
Forearm Z -score	−0.519	1.346	−1.313	1.660	<0.0001

P value is given for gender difference.

LS Z -score cannot be calculated due to the deletion of several vertebrae.

^a Western-based standards include manufacturer peak BMD for the lumbar spine, and NHANES BMD for the total hip; for population-based standards, refer to El-Hajj et al. [18].

Impact of database selection on osteoporosis risk assessment

The local database was driven from a population-based random sample individuals including 150 women and 63 men [18]. The impact of database selection was assessed through the following:

- (1) Comparison of sensitivity and specificity for prevalent vertebral fractures of the T -score ≤ -2.5 threshold using local versus NHANES database.
- (1) Comparison of estimates for fracture risk (RR/SD decrease in BMD) using local versus NHANES database.

Statistical analyses

Statistical analysis was performed by gender and estimates reported accordingly. The statistical analyses were performed using STATA software version 7 and SPSS software version 10.0 (SPSS, Chicago, IL, USA). Significance was set at a $P < 0.05$; p values were unadjusted for multiple testing. Estimates were provided with the 95% confidence interval between brackets.

Results

Clinical characteristics and bone density data

The clinical characteristics of the study population are summarized in Table 1. Mean age of the study group was 73.6±5.1 years. Women had higher BMI than men, were less likely to smoke or have smoked, and spent less time outdoors. Both men and women had a lower BMD at the total hip, femoral neck, and forearm when compared to age- and gender-matched western controls (Table 2). Risk factor distribution is described in Table 4.

Prevalence of vertebral fractures and osteoporosis

A total of 432 subjects aged 65 to 84 years, 282 women and 150 men, were studied, as spine X-rays were missing for 17 subjects (10 women and 7 men) and 11 subjects with

Table 3
Prevalence of vertebral fracture and osteoporosis (total hip *T*-score < -2.5 using NHANES database) by gender and age group (65–74 and 75–84 years of age)

	Women			Men		
	<i>N</i>	VF (%)	OP (%)	<i>N</i>	VF (%)	OP (%)
Age group (years)						
65–74	168	26 (15.5)	45 (26.8)	73	9 (10.1)	12 (16.4)
75–84	114	30 (26.3)	48 (42.1)	79	9 (14.8)	23 (29.1)
Total	282	56 (19.9)	93 (33.0)	150	18 (12.0)	35 (23.0)
<i>P</i> -value ^a		0.0251	0.0072		0.8583	0.0637

VF %: prevalence of vertebral fracture in percent.

OP %: prevalence of osteoporosis in percent.

^a Between age groups: “65–74 years” versus “75–84 years”.

hyperparathyroidism defined as serum calcium ≥ 10.5 mg/dl and PTH above the upper limit of normal (76 pg/ml) were excluded (Table 3).

Seventy-four subjects (56 women and 18 men) were identified with at least one definite vertebral fracture, between T4 and L5, giving a prevalence of 19.9% [15.4–25.0] in women and 12.0% [7.3–18.3] in men (Table 4).

In the overall study group, using the NHANES database, one hundred twenty seven subjects (93 women and 34 men) were identified with osteoporosis defined as total hip *T*-score ≤ -2.5 giving a prevalence of 33.0% [27.5–38.8] in women and 22.7% [16.2–30.2] in men.

BMD distribution in subjects with and without vertebral fractures

BMD distribution by gender in subjects with and without prevalent vertebral fractures is summarized in Table 4. There

were no differences in lumbar spine BMD between subjects with and without vertebral fractures, in both genders. Conversely, total hip and femoral neck BMD were significantly lower among subjects with vertebral fractures than subjects without vertebral fractures, in both genders. Forearm BMD was lower in women but not in men with vertebral fractures. Using the NHANES reference, the prevalence of osteoporosis, defined as total hip *T*-score ≤ -2.5 , among subjects with vertebral fracture, was 51.8% [38.0–65.3] in women and 38.9% [17.3–64.3] in men, compared to 28.3% [22.5–34.7] in women and 20.5% [13.9–28.3] in men without vertebral fractures.

Impact of database selection on DXA sensitivity and specificity for vertebral fractures

Compared to the NHANES database, the proportion of subjects with a BMD-based diagnosis of osteoporosis (total hip *T*-score ≤ -2.5) was lower when using a population-specific database [18]. Using peak BMD derived from Lebanese subjects [18], osteoporosis at total hip was present in 14.2% [10.3–18.8] of women and 2.7% [0.7–6.7] in men. Using men's population-specific database, osteoporosis prevalence in men was unchanged at 2.7% [0.7–6.7]. In subjects with vertebral fractures, osteoporosis prevalence was 26.8% [15.8–40.3] in women and 11.1% [1.4–34.7] in men.

Using the total hip NHANES database the sensitivity for prevalent vertebral fracture was 51.8% [38.0–65.3] in women and 38.9% [17.3–64.3] in men, and specificity was 71.5% [65.3–77.2] in women and 79.9% [71.2–85.6] in men.

Using our population-specific database, sensitivity for prevalent vertebral fracture was 26.8% [15.8–40.3] in women

Table 4
Distribution of risk factors for vertebral fracture in elderly aged 65 to 84 years

Covariate, mean (SD)/% [95% CI]	Women			Men		
	VF, <i>N</i> =56	No VF, <i>N</i> =226	<i>P</i> value	VF, <i>N</i> =18	No VF, <i>N</i> =132	<i>P</i> value
Age (years)	75.4 (5.0)	73.0 (5.2)	0.002	75.2 (5.7)	73.8 (4.9)	0.27
Height (cm)	148.2 (6.7)	151.2 (6.2)	0.002	161.1 (6.0)	163.3 (6.6)	0.19
Weight (kg)	67.3 (13.5)	70.1 (15.8)	0.23	71.1 (11.4)	72.5 (12.2)	0.62
BMI	30.6 (5.9)	30.7 (6.7)	0.93	27.3 (3.3)	27.2 (4.1)	0.93
Smoking	25.0%	29.6%	0.49	27.8%	35.6%	0.51
Falls	48.2%	35.0%	0.20	38.9%	25.2%	0.22
Past FF	46.4%	23.9%	0.001	38.9%	30.5%	0.59
Family FF	17.9%	14.2%	0.49	16.7%	12.1%	0.47
LS BMD	0.740 (0.15)	0.775 (0.13)	0.6	0.835 (0.167)	0.893 (0.149)	0.5
LS <i>T</i> -score	-2.8 (1.13)	-2.45 (1.15)	0.08	-2.3 (1.5)	-1.76 (1.32)	0.07
TH BMD	0.673 (0.211)	0.744 (0.121)	0.0002	0.792 (0.158)	0.855 (0.127)	0.06
TH <i>T</i> -score	-2.51 (1.09)	-1.93 (1.01)	0.0002	-2.15 (1.22)	-1.67 (0.98)	0.06
FN BMD	0.570 (0.08)	0.624 (0.08)	0.0001	0.626 (0.09)	0.674 (0.096)	0.05
FN <i>T</i> -score	-3.24 (1.0)	-2.71 (0.85)	0.0001	-3.20 (0.87)	-2.77 (0.87)	0.05
TR BMD	0.474 (0.109)	0.527(0.098)	0.0004	0.568 (0.136)	0.615 (0.110)	0.10
TR <i>T</i> -score	-2.75 (1.22)	-2.16 (1.09)	0.0004	-2.08 (1.24)	-1.66 (1.00)	0.10
FA BMD	0.469 (0.087)	0.524(0.079)	0.0000	0.658 (0.115)	0.663 (0.086)	0.83
FA <i>T</i> -score	-3.75 (1.45)	-2.84 (1.32)	0.0000	-2.99 (2.17)	-2.89 (1.63)	0.83
OP	51.8%	28.3%	0.001	38.9%	20.5%	0.07

BMI: body mass index, past FF: past history of fragility fracture, family FF; family history of fragility fracture, TH: total hip, BMD: bone mineral density, TR: trochanter, FN: femoral neck, LS: lumbar spine (L1–L4), FA: forearm (distal-third of the radius), OP: osteoporosis defined as total hip *T*-score ≤ -2.5 .

T-scores are derived from western- and population-based standards. Western-based standards include manufacturer peak BMD for the lumbar spine, and NHANES BMD for the total hip; for population-based standards, refer to El-Hajj et al. [19].

and 11.1% [1.4–34.7] in men, and specificity was 88.5% [83.7–92.3] in women and 98.5% [94.7–99.8] in men.

The area under the curve for identifying subjects with prevalent vertebral fractures was 0.65 using the NHANES database and 0.57 using the Lebanese population-based database in women. For men, similarly derived estimates were 0.64 and 0.57, respectively. Values were not statistically different across databases.

Impact of database selection on BMD–fracture relationship measured as relative risk (RR) per SD decrease in BMD

RR of vertebral fracture per SD decrease in total hip BMD varied a little with change in the reference database. With the NHANES reference peak, age-adjusted RR per unit decrease in total hip *T*-score was 1.61 [1.17–2.23] in women and 1.59 [0.94–2.72] in men. Using Lebanese women's peak, age-adjusted RR estimate was 1.49 [1.14–1.95] in women and 1.43 [0.95–2.16] in men, and with our men's population-specific peak, RR was 1.66 [0.93–2.94] in men.

Discussion

Data on vertebral fracture prevalence in the Eastern Mediterranean is very scarce. Bone density in the Lebanese elderly is a bit lower than that of age- and gender-matched western counterparts. Similar findings were observed in the young adult population with a lower peak BMD compared to western counterparts [18]. Such a difference could be explained by body size issue as well as environmental and lifestyle factors such as vitamin D status, protein intake and physical activity patterns.

However the prevalence of vertebral fractures and osteoporosis in our elderly population and fracture risk estimates based on bone density are similar to figures reported in western Caucasian populations as reported in a recent review [1] where prevalence of vertebral fracture is between 18% and 26% including cohorts such as SOF, EPIDOS, EPOS and cohorts from Rochester and the Netherlands. Our results suggest that osteoporosis health burden would be similar in our population. Such findings are relevant for osteoporosis control programs in the Eastern Mediterranean Region.

A further relevant finding is the similar mean age of women and men with vertebral fracture while mean BMD is significantly lower in women, suggesting a differential effect between genders of non-BMD-related factors on the risk of vertebral fracture. However this may be related to the mode of selection of our sample, setting lower and upper age limits for both genders.

The prevalence of osteoporosis by DXA is dependent on database selection. Using a locally driven *T*-score resulted in a lower prevalence of osteoporosis and more so in men compared to women. With the NHANES database, the prevalence of osteoporosis was more consistent with findings from other Caucasian populations [1]. This is a direct consequence of using different cutoffs for subject classification based on the *T*-score.

Similarly, DXA sensitivity for vertebral fracture is dependent on database selection. Of course it is not meant to use DXA for the diagnosis of vertebral fracture. Sensitivity is here a measure

of the correlation between osteoporosis defined by DXA and osteoporosis defined by X-ray in the presence of vertebral fracture. The NHANES derived total hip *T*-score has higher sensitivity than the population-specific total hip *T*-score but lower specificity. Overall, the use of a population-specific database does not improve significantly the diagnostic performance of DXA for prevalent vertebral fractures. Furthermore, using gender-specific database does not change significantly the results in men. This is to suggest that choosing a population-specific database instead of the NHANES database will translate into a calculated *T*-score that merely reflects the difference between the NHANES and the population-specific peaks but that difference does not account for the complex relationship between bone density and vertebral fracture risk. When we look at BMD–fracture relationship as an age and gender adjusted relative risk of vertebral fracture per SD decrease in BMD, relative risk remains almost unchanged across the two databases. This is in favor of keeping use of the NHANES database as universal reference as recommended by the International Osteoporosis Foundation. Similar findings have been reported among other Caucasian populations when population-specific and densitometer-specific databases were compared [35].

Epidemiological characteristics of prevalent vertebral fractures in our population are concordant with the general knowledge about osteoporosis in Caucasian populations [36]. Prevalence of vertebral fractures is significantly higher in women compared to men. Prevalence increases with age, subjects in the 75–84 decade having almost twice the risk of vertebral fracture as compared to those in the 65–74 decade (Table 3). Significant association is found between prevalent vertebral fractures and known risk factors such as loss of height, previous history of fragility fracture, and propensity to falls.

Among the commonest risk factors for vertebral fracture reported in the literature [25], those found to be significant in our study population are gender, age, height and previous fragility fracture. When osteoporosis defined as total hip *T*-score ≤ -2.5 is the dependent variable, significant risk factors are gender, age and weight. We failed to observe statistical significance for BMI and smoking. However, the corresponding RR reported in two recent meta-analyses [37–41] is rather small and this may account for the lack of statistical significance in our relatively small sample. Our findings about clinical risk factors are not modified when we replace the NHANES derived *T*-score with our population-driven *T*-score.

This population-based study has some limitations. First, the Greater Beirut population may not be adequately representative of the whole population with some differences regarding daily living lifestyle pattern, anthropometric characteristics such as BMI, risk factors prevalence and vitamin D status in particular [42]. This might have affected RR estimates for the various risk factors. However, since the population living in the area of Greater Beirut is a balanced mixture of the various communities and regions constitutive of the country, we believe the impact on prevalence estimate is limited. Second, assessment of the impact of database selection on BMD–fracture relationship is based on cross-sectional data. Yet several studies have shown that results obtained from prospective studies regarding probability of

fracture and BMD distribution were comparable to those obtained from large cross-sectional studies. Third, our sample size is relatively small particularly for men, with a small number of subjects with vertebral fracture and this may have prevented us from finding statistical significance for some common predictors of vertebral fracture with small excess risk. This may also account for the marginal statistical significance observed in lumbar spine and hip BMD in men between subjects with and without vertebral fractures while the absolute mean difference was of similar range to that observed in women and yet statistically significant. Another possibility would be that the attributable risk of fracture that relates to BMD in men might differ from that in women.

In conclusion, the prevalence of vertebral fractures between age 65 and 85 in our population was estimated at 19.9% [15.4–25.0] in women and in 12.0% [7.3–18.3] in men. The prevalence of osteoporosis by DXA using total hip was 33.0% [27.5–38.8] in women and 22.7% [16.2–30.2] in men. The prevalence of osteoporosis was sensitive to database selection and the NHANES database provided higher sensitivity for vertebral fracture than our population-specific database. The RR of vertebral fracture per SD decrease in BMD remained unchanged across the two databases. In women, RR estimates were 1.61 [1.17–2.23] and 1.49 [1.14–1.95] in the NHANES and the local database, respectively, and in men 1.59 [0.94–2.72] and 1.43 [0.95–2.16].

Our findings were in concordance with the IOF recommendations for the use of a universal database as opposed to a local database for fracture risk assessment and could be used for the implementation of a unified fracture risk assessment paradigm in Lebanon, and possibly the Eastern Mediterranean Region along with the WHO initiative. Further prospective studies on fracture risk assessment in the Eastern Mediterranean Region are needed to help better control of the expected epidemic.

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