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Title: Osteoporotic fractures, DXA and fracture risk assessment: Meeting future challenges in the Eastern Mediterranean Region

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Abstract: Objectives: To report on the burden of osteoporotic fractures in the Eastern Mediterranean Region (EMR) and the use of bone mineral density (BMD) DXA databases for osteoporosis diagnosis. Methods: PubMed electronic database was reviewed using the following MeSH terms: "Hip fractures", "Fractures, Compression", "Radius Fractures", "Osteoporosis", "Bone density" and "Middle East" up to July 2009.

Results: Incidence of hip fractures varied across the EMR between 100 to 295 per 100,000 person-years in women and 71 to 200 per 100,000 person-years in men. No data was found on other non-vertebral osteoporotic fractures. Prevalence of radiographic vertebral fractures above age 65 ranged between 15% to 25% in women and 7.3% to 18% in men. By 2020, the number of hip fractures above age 50 would increase by 20%. DXA manufacturer's reference curves for the spine were higher than population specific ones. At the hip, NHANES and population-based curves were comparable. Estimates of relative risk of vertebral fracture per SD decrease in BMD using NHANES and local dataset were similar, 1.61 [1.17-2.23] and 1.49 [1.14-1.95] respectively.

Conclusions: The EMR is similar to southern Europe regarding incidence rates of hip fracture, suggesting the health burden to be as significant. Using DXA at the hip, population specific reference databases did not perform better than NHANES on which the FRAX model has been developed highlighting the need for reviewing fracture risk assessment strategies in the EMR.

## **Journal of Clinical densitometry**

While epidemiological evidence on osteoporosis health burden is high in developed countries and osteoporosis appears on the agenda of corresponding health authorities, similar data remain scattered in developing countries and particularly in the Eastern Mediterranean region.

This is to submit a review paper on osteoporosis in the Eastern Mediterranean Region titled: **“Osteoporotic fractures, DXA and fracture risk assessment: meeting future challenges in the Eastern Mediterranean Region”** aiming at filling the gap in this region and providing reference for further epidemiological research in the field.

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Looking forward,

Beirut, March 4, 2011

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Running title: **Osteoporosis in Eastern Mediterranean Region**

## **Osteoporotic fractures, DXA and fracture risk assessment: Meeting future challenges in the Eastern Mediterranean Region**

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I would like to thank the reviewers for their valuable comments.

All of them have been addressed.

1. Tables and figures were revised for more clarity as recommended.
2. Tables and figures have been references in the results section and not only in the discussion section
3. Abbreviations were explained
4. Comparisons with references from the MEDOS and other relevant studies have been added.
5. The English grammar has been reviewed
6. The issue of rural versus urban was also mentioned in the discussion since data in the EMR are limited that respect.
7. Abbreviations for GE lunar and Hologic were made as recommended
8. Relevant explanations about the FRAX model were added
9. And finally all the typing errors referred to by the second reviewer were corrected

Once again I thank the reviewers for their input.

Sincerely,

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4 **Osteoporotic fractures, DXA and fracture risk assessment:**  
5 **Meeting future challenges in the Eastern Mediterranean Region**  
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33 Running title: **Osteoporosis in Eastern Mediterranean Region**  
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4 **INTRODUCTION**  
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7 The health burden of osteoporosis in developed countries has been acknowledged by  
8 health authorities including the World Health Organization (WHO) leading to a series of  
9 recommendations and guidelines on prevention, screening and management [1-8]. Demographic  
10 prospects in developing countries with increased life expectancy, high prevalence of sedentary  
11 lifestyle and smoking all lead to projections that the burden of osteoporosis will increase  
12 significantly in the near future [9].  
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15 The large variability in the incidence of non-vertebral fractures, and particularly hip  
16 fractures, is well recognized and may reflect the contribution of additional risk factors beyond  
17 bone mineral density, i.e. proximal femur anatomy, body mass index, daily living conditions and  
18 the numerous risk factors of falling [10-14]. Information regarding the epidemiology of non-  
19 vertebral osteoporotic fractures in the Eastern Mediterranean region (EMR) remains quite  
20 limited.  
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23 The WHO operational definition of osteoporosis that is based on a bone mineral density  
24 (BMD) T-score  $\leq -2.5$  using central Dual Energy X-Ray Absorptiometry (DXA) [1] has raised a  
25 debate in the literature regarding the appropriate reference database one should use, that is be it  
26 “population specific”, or “universal”, a question that has direct bearing with regard to case  
27 finding strategies and fracture risk assessment [15-20]. Although both the International  
28 Osteoporosis Foundation (IOF) and International Society for Densitometry (ISCD) recommend  
29 the use of a standard universal database, namely the National Health and Nutrition Examination  
30 Survey (NHANES) database at the hip, this recommendation has not been implemented in many  
31 countries in the Eastern Mediterranean Region (EMR).  
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36 **OBJECTIVES:**  
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38 The aim of this paper is to report on the epidemiologic evidence relevant to the health  
39 burden of osteoporosis and the different reference DXA based datasets used for T-score  
40 determination in the EMR.  
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43 **METHODS**  
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45 A literature review was done through the PubMed electronic database from 1966 until  
46 September 2009. Keywords were selected from the MeSH thesaurus. The first query used the  
47 following MeSH terms “**Hip fractures**”[MeSH] AND “**Middle-East**”[MeSH] and identified  
48 73 papers. The second query “**Fractures, Compression**”[MeSH] AND “**Middle East**”[MeSH]  
49 provided no results. The third query “**Radius Fractures**”[MeSH] AND “**Middle East**”[MeSH]  
50 identified 4 papers not relevant to our study purposes. The fourth query “**osteoporosis**”[Mesh]  
51 AND “**Middle East**”[MeSH] identified 186 papers. The fifth query “**bone density**”[Mesh]  
52 AND “**Middle East**”[MeSH] identified 137 papers.  
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55 All papers with a title and abstract relevant to the study were reviewed. Related  
56 references, with titles relevant to the study objectives, were also reviewed.  
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58 Demographic data prospects were obtained from the following website:  
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## 7 8 **RESULTS** 9

### 10 *Incidence of osteoporotic fractures and basic characteristics* 11

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13 Six studies reported on hip fracture incidence and provided characteristics of subjects  
14 with such fractures. In five studies, hip fracture cases were identified from hospital admissions,  
15 and incidence rates estimated with reference to the population in the catchment's area as the  
16 denominator, with extrapolation and adjustment for the general population at national level. One  
17 study was based on a hip fracture registry within a ministry of public health [27], *Figure 1*.  
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20 In Saudi Arabia, a retrospective review of case records of Saudi residents of Riyadh city,  
21 who were 40 years or older and who were admitted to any of the local acute-care hospitals over a  
22 period of 12 months was used to identify hip fracture cases. The estimated incidence of hip  
23 fracture over the age of 50 years was 100 per 100,000 person-years for females and 71 per  
24 100,000 person-years for males [21].  
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26 In Kuwait, a prospective study was conducted at a specialized orthopedic hospital which  
27 provides services to residents in the three governorates representing about 70% of the total  
28 population of Kuwait. All new hip fracture patients who were operated on or treated  
29 conservatively during a 4-year period (1992-1995) were included. The age-standardized  
30 incidence rates of hip fractures were estimated at 295 per 100,000 for females [95% CI: 238.8-  
31 350.8] and 200 per 100,000 for males [95% CI: 163.3-236.5], using the 1985 US population as a  
32 reference [22].  
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35 In Lebanon, a prospective survey that included all hospitals with orthopedic surgery  
36 departments in the capital Beirut collected information on new hip fracture cases over a three-  
37 month period. An extrapolation was made for the estimation of the annual incidence for the  
38 population of Beirut and the Lebanese population at large. The estimated annual incidence rate  
39 of hip fractures in Lebanese subjects aged 30 and above was 129 per 100,000 person-years  
40 (women: 153 per 100,000 person-years and men: 100 per 100,000 person-years) [23]. More  
41 recently, a population based study making use of the ministry of public health hip fracture  
42 registry evaluated the incidence of hip fractures in individuals age 50 and above for years 2006,  
43 2007 and 2008. Crude incidence rates in those years varied between 164 and 188 per 100,000 for  
44 females and between 88 and 106 per 100,000 for males, with a female/male ratio of 1.6-2.1. The  
45 overall mean age (SD) for hip fractures was 75.9 (9.2), 76.8(9.0) and 77.0(9.9) years in females  
46 in 2006, 2007 and 2008, respectively; and 74.4(11.6), 76.3(10.3) and 74.0(12.1) years in males.  
47 Using the US 2000 white population as a reference, the age-standardized rates for years 2006,  
48 2007 and 2008 were 370.4, 335.1 and 329.0 in females, and 109.7, 134.1 and 128.7 in males;  
49 estimates that approximated those calculated for Southern European countries, such as Spain  
50 and Portugal, in the paper describing the study [27].  
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53 In Iran, a multicenter population-based prospective study on accidental injuries was  
54 conducted in nine provinces across the country, covering about 9.5 million individuals over a 4.5  
55 months period. All patients aged  $\geq 50$  with radiographically confirmed proximal femur fractures  
56 were included. A total of 555 new cases of hip fracture (284 males, 271 females) were recorded,  
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4 leading to an estimated incidence of hip fractures of 115.2/100,000 person-years in men [95%  
5 CI: 107.2-123.7] and 115.6/100,000 person-years in women [95% CI: 107.4-124.3], [24].

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7 In Oman, data was prospectively collected on hip fracture cases in Sur hospital and the  
8 age-adjusted incidence rate of hip fractures in Omani subjects above 40 years of age was  
9 estimated at 140 per 100,000 person-years [25].

10 In Morocco, register and medical records data was collected from the five public  
11 hospitals in the province of Rabat. Hip fracture was restricted to cervical or trochanteric types.  
12 The age-adjusted one-year cumulative incidence of hip fracture was 52.1/100,000 in women  
13 [95% CI: 40.9-63.3] and 43.7/100,000 in men [95% CI: 33.3-52.2], [26].

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15 No studies on non-vertebral osteoporotic fractures, other than hip fractures, could be  
16 identified within the EMR.  
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### 18 19 *Demographic and clinical characteristics of patients with osteoporotic hip fractures*

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21 Few case-series and case-control studies have provided information on demographic  
22 characteristics of subjects with hip fractures in the EMR.

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24 *The mean age* at hip fracture was quite similar across different cases series and case-  
25 control studies in the EMR, with values between 70 and 79 years. In Saudi Arabia, a  
26 retrospective study of 43 subjects who sustained a proximal femoral fracture and were admitted  
27 to the orthopedic department of the King Fahd University Hospital in al-Khobar city between  
28 January 2001 and December 2006, reported a mean age of 72.1 years [28]. A similar  
29 retrospective study from Al-Riyadh city, reported a mean age of 73 years [21]. In Turkey, a  
30 retrospective study of 107 female patients who experienced hip fractures after the age of 60 years  
31 revealed a mean age of 74 years, with a range from 63 to 100 years [29]. In the case-control  
32 study of 274 patients with hip fractures from Lebanon, the mean age for hip fracture subjects was  
33 72.1 (8.5) years [30].

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36 *Gender ratio* consistently showed predominance of females, as expected, across the  
37 various studies from Iran, Jordan, Kuwait, Lebanon, Oman, and Saudi Arabia. The female to  
38 male ratio among hip fracture cases above the age of 50 years was reported as 1.1 in Iran, 1.2 in  
39 Morocco 1.3 in Oman, 1.4 in Saudi Arabia and Jordan, and 1.5 in Kuwait and Lebanon [22-30].

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41 *The anatomic distribution* of hip fractures was reported in three studies. In the study from  
42 Kuwait, the proportions were as follows: intertrochanteric fractures 59%, femoral neck fractures  
43 34%, and subtrochanteric fractures 7%, with no gender difference [22]. In the study from  
44 Morocco, hip fracture data was restricted to cervical and trochanteric fractures. No significant  
45 difference was found between genders in terms of cervical to trochanteric ratio; it was 0.97 in  
46 women and 1.03 in men. In the Lebanese ministry of health registry study, the proportions for  
47 femoral neck fractures was 73.9%, 71.5%, and 78.8% for years 2006, 2007 and 2008,  
48 respectively; 24.6%, 25.3%, and 18.9% for per-trochanteric fractures (both inter-trochanteric  
49 and trochanteric); and 1.4%, 3.2%, 2.2% for sub-trochanteric fractures [27].

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52 *Comorbidity* in hip fractures was addressed in two studies, whereby up to 70% had two or  
53 more co-morbid medical conditions [30-31].  
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### 55 56 *Burden of osteoporotic fractures in the EMR*

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58 *Mortality* as it related to osteoporotic hip fractures was documented in three case-series.  
59 The case-series from Turkey included 92 hip fracture patients (56 females, 36 males) who were  
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4 operated with a 36 months follow-up, and reported a 3-year mortality rate of 61% in females and  
5 50% in males [32]. Another retrospective study from Saudi Arabia reported an average 2-year  
6 mortality rate of 27% [33]. In the case-control retrospective study from Lebanon, the average  
7 mortality rate was 47%; most deaths occurred within the first year post-operatively, and  
8 mortality was significantly higher in men compared to women [30].  
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11 The *global burden* of osteoporotic fractures in terms of disability-adjusted life-years  
12 (DALYs) following fracture has been addressed in a single large population-based study in Iran,  
13 the Multicenter Study on Accidental Injuries [24]. Hip fractures generated 16,708 DALYs,  
14 comprising 8,812 (52.7%) years of life lost (YLL) and 7,896 (47.3%) years of life with disability  
15 (YLD). The authors estimated that Iran accounted for 0.85% of the global burden of hip fracture  
16 and 12.4% of that burden in the Middle East [34].  
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### 20 *Prevalence of osteoporosis using DXA with regard to reference datasets*

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23 Eight cross-sectional studies reporting osteoporosis prevalence by DXA, among  
24 postmenopausal women and the elderly population, were identified. Osteoporosis prevalence was  
25 often estimated using the manufacturer's reference curve, occasionally a population specific  
26 reference dataset, and in a single study the NHANES reference dataset.  
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29 In Iran, one cross-sectional survey collected data from 4188 individuals, 92% females,  
30 with a mean (SD) age of 53.4(11.8) years, referred to a community-based outpatient osteoporosis  
31 center in Tehran. Osteoporosis prevalence, using GELunar DPX-L (GE Lunar, Madison, WI,  
32 USA) database was 24.7% at spine, 12.4% at the hip, and 27.8% at any of the two sites [35].  
33 Another cross-sectional survey, community based, included 2085 healthy Iranian subjects (75%  
34 women), aged 20-88 years, also using a GELunar DPX database, reported osteoporosis  
35 prevalence at any site among subjects aged 50 years and older to be 36.1% in women and 24.5%  
36 in men [36].  
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38 In Turkey, a multicenter study of postmenopausal women, residing in five big cities, in  
39 four different regions of Turkey, mean age (SD) 57.6 (9.6) years, reported 30% to be  
40 osteoporotic at any site using a MetriScan Densitometer database (Alara Inc., CA, USA) [37].  
41 Another community based study, among the elderly, including 783 females and 464 males aged  
42 65 years and above and using a Hologic QDR 4500A densitometer database (Hologic, Bedford,  
43 MA, USA), reported 63.5% of women and 45.9% of men as having osteoporosis at any site [38].  
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46 In Saudi Arabia, a cross-sectional survey of 830 postmenopausal women, 50-80 years of  
47 age, evaluated at King Khalid University Hospital, Riyadh, reported 39.5% to be osteoporotic at  
48 any site using GELunar DPX densitometer [39]. Another study using simulation approach  
49 estimated osteoporosis prevalence in women aged 50-70 years at around 23% [40].  
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51 In Jordan, a study of 400 women who visited outpatient clinics at two community  
52 hospitals in Amman City, with a mean (SD) age of 53 (12) years, reported 29.6% as  
53 osteoporotic at any site using a GELunar DPX densitometer [41].  
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55 In Lebanon, one study of a population-based random sample of elderly subjects aged 65  
56 to 84 years, using the NHANES database, reported osteoporosis prevalence at total hip to be  
57 33.0% [27.5-38.8] in women and 22.7% [16.2-30.2] in men [42].  
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4 *Population specific datasets*  
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7       Eleven studies [43-53] on premenopausal women and young adult populations reported  
8 BMD and T-score distribution by site, age and gender providing estimates of mean peak bone  
9 mass mainly at the spine and the hip. Eight provided relevant epidemiological information (*see*  
10 *Figure 2 & Table 2*).  
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12       Four of these studies [43, 48, 49, and 53] reported population-based reference datasets  
13 with a properly selected random sample quite representative of the general population, including  
14 young adults. The remaining studies [44, 45, 46, 47, 50, 51, and 52] reported no explicit  
15 sampling frame or no proper random selection.  
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18       Most studies determined the prevalence of osteoporosis, defined by BMD, in their  
19 populations using peak bone mass as defined by the manufacturer's normative database and their  
20 population specific normative database. Only one study [42] compared the performance of using  
21 a population specific database versus an NHANES database to identify subjects with prevalent  
22 radiographic vertebral fractures.  
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25       In Iran, the *Iranian Multicenter Osteoporosis Study* included 5201 subjects aged from 20  
26 to more than 70 years (2340 males, mean age  $42.7 \pm 13.8$  years) by random cluster sampling from  
27 civil status registries of five major cities. DXA was performed using a GELunar DPX  
28 densitometer and the NHANES reference curve for proximal femur, with phantom cross  
29 calibration between centers. Standardized peak bone mass values were comparable to reference  
30 values from Western countries and to reported references from other Eastern Mediterranean  
31 countries [43]. Another Iranian population-based cross-sectional survey was conducted in  
32 Teheran and included 553 subjects (34% men, 66% women) randomly selected from 50 blocks  
33 in the city. DXA was performed on also and using a GELunar DPX with the manufacturer's  
34 database and reported similar findings [44], *Table 2*.  
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39       In *Kuwait*, 623 healthy Kuwaiti women, aged 20-79 years, with no explicit sampling  
40 frame, were evaluated using a GELunar DPX machine. Average peak bone mass at the spine was  
41  $1.238 \pm 0.14$  g/cm<sup>2</sup> and the hip was  $1.022 \pm 0.11$  g/cm<sup>2</sup>, slightly higher values than NHANES  
42 reference values, but the difference was not statistically significant [45], *Table 2*.  
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45       In *Saudi Arabia*, one study included 1,980 randomly selected subjects from 18 primary  
46 health care centers in Jeddah area (age range 20-79 years, 915 males and 1065 females) using a  
47 GELunar DPX machine. Average peak bone mass at total hip was estimated at  $0.992 \pm 0.17$   
48 g/cm<sup>2</sup> in females and  $1.098 \pm 0.19$  g/cm<sup>2</sup> in males, values quite comparable to the NHANES  
49 values, *Table 2*. However, using manufacturer's reference dataset, confidence interval for  
50 osteoporosis prevalence was 6.3-7.8% at the total hip compared to 1.2-4.7% when using the  
51 Saudi reference database [46]. Another study compared T-score distribution across four  
52 reference curves, two from Saudi Arabia, one from Lebanon and one from Kuwait among 1653  
53 women referred for DXA using a GELunar DPX machine at the Security Forces Hospital,  
54 Riyadh, Saudi Arabia. Saudi reference curves were comparable, while on average Lebanese  
55 reference values were lower and Kuwaiti reference values were higher than both Saudi reference  
56 curves, however no testing for statistical significance of the difference was reported [47].  
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4 In *Morocco*, a population-based survey was carried out on 569 Moroccan women and 592  
5 Moroccan men, aged between 20 and 79 years, randomly selected in the area of Rabat, using a  
6 cluster sampling frame [48-49]. DXA was performed with a GELunar Prodigy machine. Peak  
7 BMD at the total hip was  $1.029 \pm 0.11 \text{ g/cm}^2$  in women and  $1.161 \pm 0.16 \text{ g/cm}^2$  in men [49],  
8 *Table 2*. The use of the GELunar reference dataset classified 18.1% of men as osteoporotic at the  
9 spine compared to 7.4% using the Moroccan, and 7.8% using a Lebanese reference dataset. The  
10 proportion of men identified with osteoporosis at the hip were more comparable across  
11 databases, it was 6% with the Moroccan, 3.9% with the US and 5.3% with the European  
12 GELunar reference databases, [49].  
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17 In *Turkey*, one study among 323 healthy young adults (171 women, 152 men), aged 19-  
18 25 years, using Hologic QDR 4500A, reported T-scores distribution but no BMD values. Using  
19 the manufacturer's reference dataset, average T-scores at the spine and proximal femur were  
20 significantly lower than zero in both genders. Using the local population reference dataset for T-  
21 score calculation, the prevalence of low BMD defined as a T-score  $< -1$  was 14.0% at the lumbar  
22 spine and 14.6% at the femoral neck in women, and 15.8% at the lumbar spine and 17.1% at the  
23 femoral neck in men, proportions that were significantly lower than those derived using the  
24 manufacturer's database, with corresponding numbers of 50.3% and 60.8% in women, and  
25 42.8% and 30.9% in men [50]. Another study included 951 subjects (639 women and 312 men)  
26 aged from 15 to 79 years who had their BMD was measured at the calcaneus using a dual X-ray  
27 and laser Calscan (Demetech AB, Stockholm, Sweden) bone densitometer. Mean BMD value for  
28 healthy young adults (20-39 years old) was  $0.411 \pm 0.058 \text{ g/cm}^2$  in women and  $0.504 \pm 0.068$   
29  $\text{g/cm}^2$  in men. Values were on the average about 1 standard deviation lower in both genders, and  
30 across all ages-groups, as compared to those from the densitometer Swedish database [51].  
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35 In *Lebanon*, three studies were identified. The first study included 858 women and 165  
36 men aged 20-79 years, with no explicit sample selection frame, and used GELunar DPX.  
37 Lebanese BMD values were generally slightly lower than the US and European reference values  
38 in younger age groups, with smaller differences in the older age groups [52], *Table 2*. The  
39 authors reported similar age-related changes in BMD in the Lebanese in comparison to both US  
40 and European reference databases. The second study reported BMD distribution in a randomly  
41 selected young adult population using a cluster sampling frame from Beirut and its suburbs.  
42 DXA was performed in three centers, one with a Hologic 4500W, one with Hologic 4500A and  
43 the third one with GELunar DPX densitometer. Cross calibration across centers was performed  
44 by having 45 women simultaneously tested at the three centers and a linear regression was  
45 applied to allow conversion of densitometry measurements from one machine to the other. BMD  
46 values were  $1.01 \pm 0.11 \text{ g/cm}^2$  in women and  $1.01 \pm 0.13 \text{ g/cm}^2$  in men at the lumbar spine, and  
47  $0.84 \pm 0.10 \text{ g/cm}^2$  in women and  $0.94 \pm 0.15 \text{ g/cm}^2$  in men at the total hip, on the Hologic  
48 densitometer. The corresponding values were  $1.18 \pm 0.12 \text{ g/cm}^2$  in women and  $1.18 \pm 0.14 \text{ g/cm}^2$  in  
49 men at the lumbar spine, and  $0.97 \pm 0.11 \text{ g/cm}^2$  in women and  $1.07 \pm 0.15 \text{ g/cm}^2$  in men at the total  
50 hip, on GELunar DPX [53]. Whether measured on GELunar or Hologic, the T-scores derived  
51 with reference to the NHANES database were significantly less than zero in women both the  
52 spine and the hip. The NHANES-derived total hip mean T-score (SD) was -0.8 (0.9) for women,  
53 and -0.7 (1.0) for men, both being significantly less than zero [53].  
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58 The third study included a randomly selected sample of elderly subjects from Beirut and  
59 its suburbs using the same sampling frame of the peak BMD study. DXA was performed in two  
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4 centers, one with Hologic 4500W machine and the one with Hologic 4500A, with cross  
5 calibration between both centers. In addition standard X-rays of the spine were performed, and  
6 vertebral fractures were assessed using the Genant semi-quantitative technique, thus providing  
7 the only published paper on the prevalence of radiographic vertebral fractures in the EMR, and  
8 allowing for an estimation of the relative risk of vertebral fracture in association with BMD loss.  
9 With reference to NHANES, the prevalence of osteoporosis by BMD at total hip was 33.0%  
10 [27.5-38.8] in women and 22.7% [16.2-30.2] in men. Excluding grade I fractures, the prevalence  
11 of vertebral fractures, was estimated at 19.9% [15.4-25.0] in women and 12.0% [7.3-18.3] in  
12 men. Compared to the NHANES, the population specific database was less sensitive to identify  
13 subjects with prevalent radiographic vertebral fractures. However, as expected, the relative risk  
14 of vertebral fracture per SD decrease (RR/SD) in BMD was similar across the two databases. In  
15 women, RR/SD was 1.61 [1.17-2.23] using the NHANES database and 1.49 [1.14-1.95] using  
16 the local database. In men, the figures were 1.59 [0.94-2.72] using NHANES and 1.43 [0.95-  
17 2.16] using the local dataset [42].  
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## 23 DISCUSSION

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26 Similarly to other large geographic areas worldwide, the incidence rate of hip fractures  
27 varies across population studies in the EMR, although within a narrower range, estimates ranging  
28 from 100 to 295/100,000 person-years in women and 71 to 200/100,000 person-years in men,  
29 *Figure 1*.  
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32 Limitations regarding hip fracture estimates in the EMR include the small number of  
33 studies available, the frequent lack of clear inclusion criteria, the relative short time frame and  
34 retrospective nature of the studies, as well as the lack of large epidemiologic population- based  
35 cohorts, across the region. Despite these limitations, the currently available hip fracture  
36 incidence rates in the EMR were similar to those reported in other Southern European and  
37 Mediterranean countries, as reported in the Mediterranean Countries Osteoporosis Study  
38 (MEDOS) study and lower than reported rates in Northern Europe, North America and Australia  
39 [10, 11, 56-65]. Indeed, in the MEDOS study, hip fracture incidence rates in France varied  
40 between 100 and 250 per 100,000 person-years and were below 100 per 100,000 person-years in  
41 Southern European countries (56). In the European Prospective Osteoporosis Study (EPOS), hip  
42 fracture incidence rates were 130 [(95% CI: 80-170] per 100,000 person-years in women and 80  
43 [95% CI: 40-100] per 100,000 person-years in men (64). The US Women's Health Initiative  
44 (WHI) study reported an annualized incidence rate of hip fractures 160 per 100, 000 person-  
45 years (65), and the Dubbo cohort, which included subjects aged 60 and above, incidence rates of  
46 hip fracture were 759 [95% CI: 647–871] per 100,000 person-years, in women and 329 [95% CI:  
47 241–417] per 100,000 person-years in men (11).  
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53 Female to male gender ratio among subjects with hip fracture ranged between 1.1 and  
54 1.5, a ratio that is somewhat lower than what has been reported in US and European population,  
55 possibly reflecting both regional epidemiological characteristics and different gender based life  
56 expectancies [9], *Figure 3*. Mean age at hip fracture was similar across all surveys in the area,  
57 ranging between 72 and 74 years, and was significantly lower than the mean reported age  
58 reported in developed countries, again reflecting the shorter life expectancy in the EMR, in both  
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4 genders. All reported age distributions of hip fracture incidence rates across the EMR show  
5 consistently the exponential increase beyond age 70, *Figure 1*.  
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8 In one study in Turkey authors addressed the issue of difference in incidence rates of hip  
9 fracture between rural and urban areas as they found higher rates in rural versus urban  
10 populations. Education as a social determinant was a significant confounding factor since  
11 difference between rural and urban rates was significantly reduced when adjusted for educational  
12 level. Higher energy fractures in rural areas was raised as a hypothetical explanation for their  
13 findings which were opposite to common observations of higher incidence rates of hip fracture in  
14 urban populations.  
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17 The prevalence of radiographic vertebral compression fractures above age 65 was  
18 estimated at around 20% in Lebanese women and 12% in Lebanese men by our group [42].  
19 These figures are similar to those reported in European countries (13), providing some evidence  
20 on the burden of osteoporosis in EMR countries. No epidemiological data on non-hip, non-  
21 vertebral, osteoporotic fractures in the EMR could be identified.  
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24 The prevalence of osteoporosis based on BMD at any skeletal site among  
25 postmenopausal women and men above age 50 is quite comparable across EMR countries, and  
26 was close to 30% in several studies in women and close to 20% in 2/3 studies in men, based on  
27 manufacturer's database [36-42], *Table 1*. However manufacturer's reference values at the spine  
28 were overall significantly higher than spine BMD values in population-based datasets across the  
29 various studies in the EMR, and therefore osteoporosis prevalence could be overestimated or  
30 underestimated depending on the reference dataset used. Interestingly, population-based  
31 reference values at the hip were often closer to the NHANES reference values. Moreover, mean  
32 BMD values were quite comparable across populations and showed a similar decline of BMD  
33 with age, *Figure 2*. Finally, data relating BMD to radiographic vertebral fractures in a cohort of  
34 elderly subjects in Lebanon revealed similar estimates for the relative risk of vertebral fracture  
35 per SD decrease in BMD whether a population specific or the NHANES dataset were used.  
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40 No evidence was found to support using local or regional databases instead of the  
41 NHANES as a universal database. Based on the current evidence, we believe that along with the  
42 IOF and ISCD recommendations [17,19], the NHANES database would be the most appropriate  
43 database to be used in the EMR. This would help comparisons across populations in the EMR  
44 and between the EMR and other parts of the world. In addition, the use of the NHANES would  
45 ensure consistency in values obtained with those derived using the on-line fracture risk  
46 assessment calculator, FRAX, a calculator that is now available for 3 countries in the EMR  
47 region, namely Turkey, Lebanon and Jordan [55].  
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51 From a public health perspective, mortality figures for hip fracture in the EMR although  
52 limited are quite alarming. Mortality rates exceeded 25% at two years and reached 60% at three  
53 years, despite a relatively younger mean age of individuals with hip fractures in the EMR  
54 compared to developed countries [30-32-33]. Demographic prospects for the next decade suggest  
55 a significant increase in the proportion of subjects above age 65 in the Middle East and North  
56 Africa (MENA) region, *Figure 3*. The proportion of women above age 65 would rise by about  
57 30%, from 4.8% in 2010 to 6.0% in 2020. Similarly for men the increase would be about 25%  
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4 from 4.0% to 4.9%. Such demographic changes would translate in 17% increase in the number of  
5 hip fractures over the next decade in both genders. Accordingly, the expected number of hip  
6 fractures among subjects above age 65 in the MENA region in 2020 would be around 300,000 in  
7 women and 250,000 in men, [9].  
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## 10 **CONCLUSIONS**

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12 The health burden of osteoporosis in the EMR is quite significant. Hip fracture incidence  
13 ranged between 100 and 295 per 100,000 person-years across the EMR, in postmenopausal  
14 women, with no major differences between countries in the EMR, and approximating rates in  
15 Southern Europe. Female to male ratio among hip fracture subjects ranged between 1.1 and 2.4  
16 and the mean age at the time of hip fracture ranged between 71 and 79 years. Mortality rates  
17 exceed 25% by two years following fracture.  
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21 Osteoporosis prevalence using DXA was quite similar across study populations in the  
22 EMR, around 30% at the lumbar spine when BMD is measured using the manufacturer's  
23 reference database. T-score derived from population specific databases was often slightly lower  
24 than those obtained using wither the GELunar and or Hologic databases. Mean BMD were also  
25 comparable between countries and the age-related decrease in BMD was similar across all  
26 databases, in both genders and in all studies. Estimates of the relative risk of vertebral fracture  
27 per SD decrease in BMD in an elderly Lebanese cohort were similar whether the NHANES or a  
28 population specific database was used.  
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32 Overall, population specific datasets seemed no better than the NHANES dataset for  
33 fracture risk assessment using DXA, thus justifying the use of the universal NHANES database  
34 for osteoporosis assessment in the EMR, as is recommended in other regions worldwide.  
35 Furthermore, the FRAX calculator is based on the NHANES database, and is now available for  
36 Turkey, Lebanon and Jordan, thus allowing absolute fracture risk assessment and health policy  
37 decision making regarding osteoporosis treatment in several countries in the EMR.  
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41 Demographic prospects in the MENA region suggest the burden of osteoporosis will rise  
42 significantly by 2020, calling for cost-effective health policies to reduce the incidence of hip  
43 fractures and fracture-related mortality and morbidity.  
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## REFERENCES

1. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. World Health Organ Tech Rep Ser. 1994;843:1-129
2. Cole ZA, Dennison EM, Cooper C (2008) Osteoporosis epidemiology update. *Curr Rheumatol Rep* 10(2):92-96
3. Davison KS, Kendler DL, Ammann P, Bauer DC, Dempster DW, Dian L, Hanley DA, Harris ST, McClung MR, Olszynski WP, Yuen CK (2009) Assessing fracture risk and effects of osteoporosis drugs: bone mineral density and beyond. *Am J Med* 122(11):992-997
4. Cummings SR, Melton LJ (2002) Epidemiology and outcomes of osteoporotic fractures. *Lancet* 359(9319):1761-1767
5. Holroyd C, Cooper C, Dennison E (2008) Epidemiology of osteoporosis. *Best Pract Res Clin Endocrinol Metab* 22(5):671-685
6. Keen RW (2003) Burden of osteoporosis and fractures. *Curr Osteoporos Rep* 1(2):66-70
7. Kanis JA, McCloskey EV, Johansson H, Oden A, Melton LJ 3rd, Khaltsev N (2008) A reference standard for the description of osteoporosis. *Bone*. 2008 Mar; 42(3):467-75.
8. Kanis JA, Johnell O, Oden A, De Laet C, Mellstrom D., (2004) Epidemiology of osteoporosis and fracture in men. *Calcif Tissue Int* 75:90-99
9. World Bank.  
<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTHEALTHNUTRITIONANDPOPULATION/>. Last accessed March 3, 2010
10. Johnell O, Kanis J. A. (2006) An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int* 17:1726-1733
11. Chang KP, Center JR, Nguyen TV, Eisman JA (2004) Incidence of hip and other osteoporotic fractures in elderly men and women: Dubbo Osteoporosis Epidemiology Study. *J Bone Miner Res* 19(4):532-536
12. Roy DK, O'Neill TW, Finn JD, et al; European Prospective Osteoporosis Study (EPOS) (2003) Determinants of incident vertebral fracture in men and women: results from the European Prospective Osteoporosis Study (EPOS). *Osteoporos Int* 14(1):19-26
13. Lunt M, O'Neill TW, Felsenberg D, Reeve J, Kanis JA, Cooper C, Silman AJ; European Prospective Osteoporosis Study Group (2003) Characteristics of a prevalent vertebral deformity predict subsequent vertebral fracture: results from the European Prospective Osteoporosis Study (EPOS). *Bone* 33(4):505-513

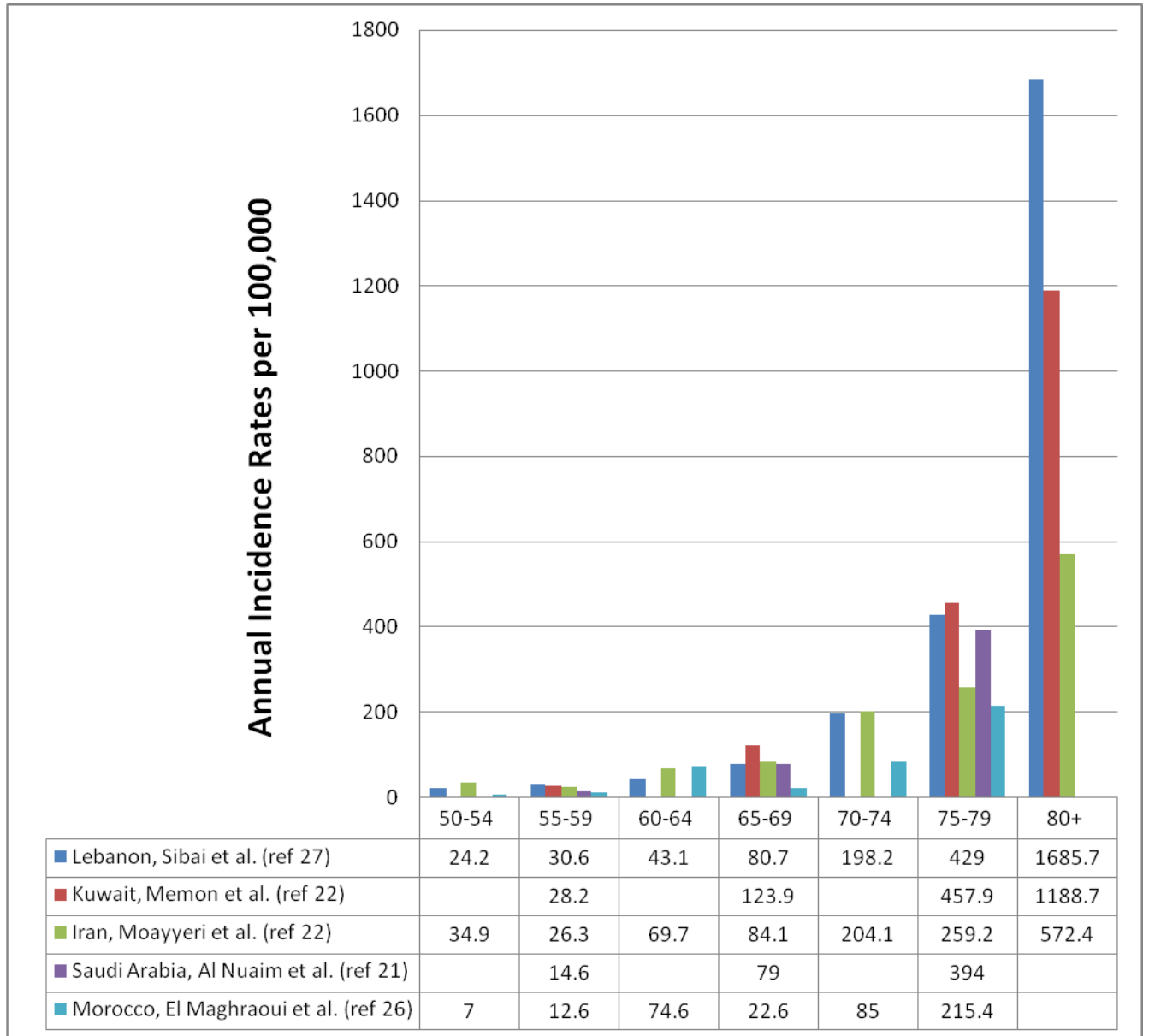
- 1  
2  
3  
4  
5  
6 14. Kanis JA, Oden A, Johnell O et al (2007) The use of clinical risk factors enhances the performance  
7 of BMD in the prediction of hip and osteoporotic fractures in men and women. *Osteoporos Int*  
8 18(8):1033-1046  
9
- 10  
11 15. Kanis JA, Glüer CC. An update on the diagnosis and assessment of osteoporosis with densitometry.  
12 Committee of Scientific Advisors, International Osteoporosis Foundation. *Osteoporos Int.*  
13 2000;11(3):192-202  
14
- 15  
16 16. Kanis JA, Johansson H, Oden A, McCloskey EV (2009) Assessment of fracture risk. *Eur J Radiol.*  
17 Sep;71(3):392-7  
18
- 19  
20 17. Binkley N, Bilezikian JP, Kendler DL, Leib ES, Lewiecki EM, Petak SM; International Society for  
21 Clinical Densitometry (2006) Official positions of the International Society for Clinical  
22 Densitometry and Executive Summary of the 2005 Position Development Conference. *Clin*  
23 *Densitom* 9(1):4-14  
24
- 25  
26 18. Looker AC, Wahner HW, Dunn WL, Calvo MS, Harris TB, Heyse SP, Johnston CC Jr, Lindsay R  
27 (1998) Updated data on proximal femur bone mineral levels of US adults. *Osteoporos Int* 8(5):468-  
28 489  
29
- 30  
31 19. Dawson-Hughes B, Looker AC, Tosteson AN, Johansson H, Kanis JA, Melton LJ 3<sup>rd</sup> (2010). The  
32 potential impact of new National Osteoporosis Foundation guidance on treatment patterns.  
33 *Osteoporos Int.* Jan;21(1):41-52  
34
- 35  
36 20. Kanis JA, McCloskey EV, Johansson H, Oden A (2009). Approaches to the targeting of treatment  
37 for osteoporosis. *Nat Rev Rheumatol.* Aug;5(8):425-31. Review  
38
- 39  
40 21. al-Nuaim AR, Kremlı M, al-Nuaim M, Sandkgi S (1995) Incidence of proximal femur fracture in an  
41 urbanized community in Saudi Arabia. *Calcif Tissue Int* 56(6):536-538  
42
- 43  
44 22. Memon A, Pospula WM, Tantawy AY, Abdul-Ghafar S, Suresh A, Al-Rowaih A (1998) Incidence  
45 of hip fracture in Kuwait. *Int J Epidemiol* 27(5):860-865  
46
- 47  
48 23. Baddoura R (2001) Incidence of hip fractures in the Lebanese population. *East Mediterr Health J*  
49 7(4-5):725-729  
50
- 51  
52 24. Moayyeri A, Soltani A, Larijani B, Naghavi M, Alaeddini F, Abolhassani F (2006) Epidemiology  
53 of hip fracture in Iran: results from the Iranian Multicenter Study on Accidental Injuries.  
54 *Osteoporos Int* 17(8):1252-1257  
55
- 56  
57 25. Shukla JJ, Khandekar RB (2008) Magnitude and determinants of osteoporosis in adult population of  
58 South Sharqiya region of Oman. *Saudi Med J* 29(7):984-988  
59
- 60  
61 26. El Maghraoui A, Koumba BA, Jroundi I, Achemlal L, Bezza A, Tazi MA (2005) Epidemiology of  
62 hip fractures in 2002 in Rabat, Morocco. *Osteoporos Int* 16(6):597-602  
63  
64  
65

- 1
- 2
- 3
- 4 27. Sibai A. M., Nasser W, Ammar W., Khalife M. J., Harb H. and El-Hajj Fuleihan G. Hip Fracture
- 5 Incidence in Lebanon: A National Registry Based Study with Reference to Standardized rates
- 6 worldwide OI (In Press).
- 7
- 8
- 9 28. Bubshait D, Sadat-Ali M (2007) Economic implications of osteoporosis-related femoral fractures in
- 10 Saudi Arabian society. *Calcif Tissue Int* 81(6):455-458
- 11
- 12
- 13 29. Unay K, Demirçay E, Akan K, Sener N (2005) Risk factors for osteoporosis in women having hip
- 14 fractures after 60 years of age. *Acta Orthop Traumatol Turc* 39(4):295-299
- 15
- 16 30. Hreybe H, Salamoun M, Badra M, Afeiche N, Baddoura O, Boulos S, Haidar R, Lakkis S,
- 17 Musharrafieh R, Nsouli A, Taha A, Tayim A, Fuleihan Gel-H (2004) Hip fractures in Lebanese
- 18 patients: determinants and prognosis. *J Clin Densitom* 7(4):368-375
- 19
- 20
- 21 31. Shakhathreh HS (2001) Analysis of fractures of the proximal femur in the Jordanian population. *Isr*
- 22 *Med Assoc J* 3(1):28-31
- 23
- 24
- 25 32. Oztürk I, Toker S, Ertürer E, Aksoy B, Seçkin F (2008) Analysis of risk factors affecting mortality
- 26 in elderly patients (aged over 65 years) operated on for hip fractures. *Acta Orthop Traumatol Turc*
- 27 42(1):16-21
- 28
- 29
- 30 33. Al-Omran A, Sadat-Ali M (2006) Is early mortality related to timing of surgery after fracture femur
- 31 in the elderly? *Saudi Med J* 27(4):507-510
- 32
- 33 34. Ahmadi-Abhari S, Moayyeri A, Abolhassani F (2007) Burden of hip fracture in Iran. *Calcif Tissue*
- 34 *Int* 80(3):147-153
- 35
- 36 35. Moayyeri A, Soltani A, Bahrami H, Sadatsafavi M, Jalili M, Larijani B (2006) Preferred skeletal
- 37 site for osteoporosis screening in high-risk populations. *Public Health* 120(9):863-871
- 38
- 39
- 40 36. Salehi I, Khazaeli S, Najafizadeh SR, Ashraf H, Malekpour M (2009). High prevalence of low bone
- 41 density in young Iranian healthy individuals. *Clin Rheumatol.*; 28(2):173-7.
- 42
- 43 37. Hamdi Kara I, Aydin S, Gemalmaz A, et al (2007) Habitual tea drinking and bone mineral density
- 44 in postmenopausal Turkish women: investigation of prevalence of postmenopausal osteoporosis in
- 45 Turkey (IPPOT Study). *Int J Vitam Nutr Res* 77(6):389-397
- 46
- 47 38. Cankurtaran M, Yavuz BB, Halil M, Dagli N, Ariogul S (2005) General characteristics, clinical
- 48 features and related factors of osteoporosis in a group of elderly Turkish men. *Aging Clin Exp Res*
- 49 17(2):108-115
- 50
- 51 39. El-Desouki MI (2003) Osteoporosis in postmenopausal Saudi women using dual x-ray bone
- 52 densitometry. *Saudi Med J* 24(9):953-956
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65

- 1  
2  
3  
4 40. Greer W, Ahmed M, Rifai A, Sandridge AL (2008) Exploring the extent of postmenopausal  
5 osteoporosis among Saudi Arabian women using dynamic simulation. *J Clin Densitom* 11(4):543-  
6 554  
7  
8  
9 41. Shilbayeh S (2003) Prevalence of osteoporosis and its reproductive risk factors among Jordanian  
10 women: a cross-sectional study. *Osteoporos Int* 14(11):929-940  
11  
12  
13 42. Baddoura R, Arabi A, Haddad-Zebouni S, Khoury N, Salamoun M, Ayoub G, Okais J, Awada H,  
14 El-Hajj Fuleihan G (2007) Vertebral fracture risk and impact of database selection on identifying  
15 elderly Lebanese with osteoporosis. *Bone* 40(4):1066-1072  
16  
17  
18 43. Larijani B, Moayyeri A, Keshtkar AA, Hossein-Nezhad A, Soltani A, Bahrami A, Omrani GH,  
19 Rajabian R, Nabipour I (2006) Peak bone mass of Iranian population: the Iranian Multicenter  
20 Osteoporosis Study. *J Clin Densitom* 9(3):367-374  
21  
22  
23 44. Larijani B, Hossein-Nezhad A, Mojtahedi A, Pajouhi M, Bastanhagh MH, Soltani A, Mirfezi SZ,  
24 Dashti R (2005) Normative data of bone Mineral Density in healthy population of Tehran, Iran: a  
25 cross sectional study. *BMC Musculoskelet Disord* 6:38  
26  
27  
28 45. Dougherty G, Al-Marzouk N (2001) Bone density measured by dual-energy X-ray absorptiometry  
29 in healthy Kuwaiti women. *Calcif Tissue Int* 68(4):225-229  
30  
31  
32 46. Ardawi MS, Maimany AA, Bahksh TM, Nasrat HA, Milaat WA, Al-Raddadi RM (2005) Bone  
33 mineral density of the spine and femur in healthy Saudis. *Osteoporos Int* 16(1):43-55  
34  
35  
36 47. Outif AM, Hendi AA, Al-Dihan AA, Al-Ghamdi SS (2004) Bone mineral density. What normative  
37 data should we use to report Saudi female patients? *Saudi Med J* 25(8):1040-1045  
38  
39  
40 48. El Maghraoui A, Guerboub AA, Achemlal L, Mounach A, Nouijai A, Ghazi M, Bezza A, Tazi MA  
41 (2006) Bone mineral density of the spine and femur in healthy Moroccan women. *J Clin Densitom*  
42 9(4):454-460  
43  
44  
45 49. El Maghraoui A, Ghazi M, Gassim S, Mounach A, Ghozlani I, Nouijai A, Achemlal L, Bezza A,  
46 Dehhaoui M (2009) Bone mineral density of the spine and femur in a group of healthy Moroccan  
47 men. *Bone* 44(5):965-969  
48  
49  
50 50. Gürlek A, Bayraktar M, Ariyürek M (2000) Inappropriate reference range for peak bone mineral  
51 density in dual-energy X-ray absorptiometry: implications for the interpretation of T-scores.  
52 *Osteoporos Int* 11(9):809-813  
53  
54  
55 51. Tuzun S, Akarirmak U, Uludağ M, Tuzun F, Kullenberg R (2007) Is BMD sufficient to explain  
56 different fracture rates in Sweden and Turkey? *J Clin Densitom* 10(3):285-288  
57  
58  
59 52. Maalouf G, Salem S, Sandid M, Attallah P, Eid J, Saliba N, Nehmé I, Johnell O (2000) Bone  
60 mineral density of the Lebanese reference population. *Osteoporos Int* 11(9):756-764  
61  
62  
63  
64  
65

- 1  
2  
3  
4 53. El-Hajj Fuleihan G, Baddoura R, Awada H, Salam N, Salamoun M, Rizk P (2002) Low peak bone  
5 mineral density in healthy Lebanese subjects *Bone* 31(4):520-528  
6  
7  
8 54. McCloskey EV, Johansson H, Oden A, Kanis JA. (2009) From relative risk to absolute fracture risk  
9 calculation: the FRAX algorithm. *Curr Osteoporos Rep. Sep*;7(3):77-83  
10  
11 55. WHO Fracture Risk Assessment tool. <http://www.shef.ac.uk/FRAX/tool.jsp> Accessed March 3,  
12 2010.  
13  
14  
15 56. Lyritis G. P. and the MEDOS Study Group. Epidemiology of Hip Fracture: The MEDOS Study.  
16 *Osteoporosis Int.* (1996) Suppl.3:S11-S15  
17  
18 57. Dargent-Molina P, Favier F, Grandjean H, Baudoin C, Schott AM, Hausherr E, Meunier PJ, Bréart  
19 G. (1996) Fall-related factors and risk of hip fracture: the EPIDOS prospective study. *Lancet.* Jul  
20 20;348(9021):145-9.  
21  
22  
23  
24 58. Dargent-Molina P, Douchin MN, Cormier C, Meunier PJ, Bréart G. EPIDOS Study Group. (2002)  
25 Use of clinical risk factors in elderly women with low bone mineral density to identify women at  
26 higher risk of hip fracture: The EPIDOS prospective study. *Osteoporos Int.* Jul;13(7):593-9.  
27  
28  
29 59. Melton LJ 3rd. (1996) Epidemiology of hip fractures: implications of the exponential increase with  
30 age. *Bone.* Mar;18(3 Suppl):121S-125S.  
31  
32 60. Kannus P, Parkkari J, Sievänen H, Heinonen A, Vuori I, Järvinen M. (1996) Epidemiology of hip  
33 fractures. *Bone.* Jan;18(1 Suppl):57S-63S  
34  
35  
36 61. Marks R. Hip fracture epidemiological trends, outcomes, and risk factors, 1970–2009. (2010)  
37 *International Journal of General Medicine*:3 1–17  
38  
39 62. Rivadeneira F, Zillikens MC, De Laet CE, Hofman A, Uitterlinden AG, Beck TJ, Pols HA (2007)  
40 Femoral neck BMD is a strong predictor of hip fracture susceptibility in elderly men and women  
41 because it detects cortical bone instability: the Rotterdam Study. *J Bone Miner Res.*  
42 Nov;22(11):1781-90.  
43  
44  
45 63. Kaptoge S, Beck TJ, Reeve J, Stone KL, Hillier TA, Cauley JA, Cummings SR. (2008) Prediction  
46 of incident hip fracture risk by femur geometry variables measured by hip structural analysis in the  
47 study of osteoporotic fractures. *J Bone Miner Res.* Dec;23(12):1892-904.  
48  
49  
50 64. Crabtree NJ, Kroger H, Martin A, Pols HA, Lorenc R, Nijs J, Stepan JJ, Falch JA, Miazgowski T,  
51 Grazio S, Raptou P, Adams J, Collings A, Khaw KT, Rushton N, Lunt M, Dixon AK, Reeve J.  
52 (2002) Improving risk assessment: hip geometry, bone mineral distribution and bone strength in hip  
53 fracture cases and controls. The EPOS study. *European Prospective Osteoporosis Study.*  
54 *Osteoporos Int.* Jan;13(1):48-54.  
55  
56  
57 65. Robbins J, Aragaki AK, Kooperberg C, Watts N, Wactawski-Wende J, Jackson RD, LeBoff MS,  
58 Lewis CE, Chen Z, Stefanick ML, Cauley J. (2007) Factors associated with 5-year risk of hip  
59 fracture in postmenopausal women. *JAMA.* Nov 28;298(20):2389-98  
60  
61  
62  
63  
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Figure 1: Hip fracture annual incidence rates (per 100,000) in women among Eastern Mediterranean Countries.



**Figure 2: Mean total femur BMD (g/cm<sup>2</sup>) by 10-years age groups in both genders across various EMR countries. Data from studies using DPX-Lunar densitometers. The NHANES database values are as provided from Lunar manufacturer.**

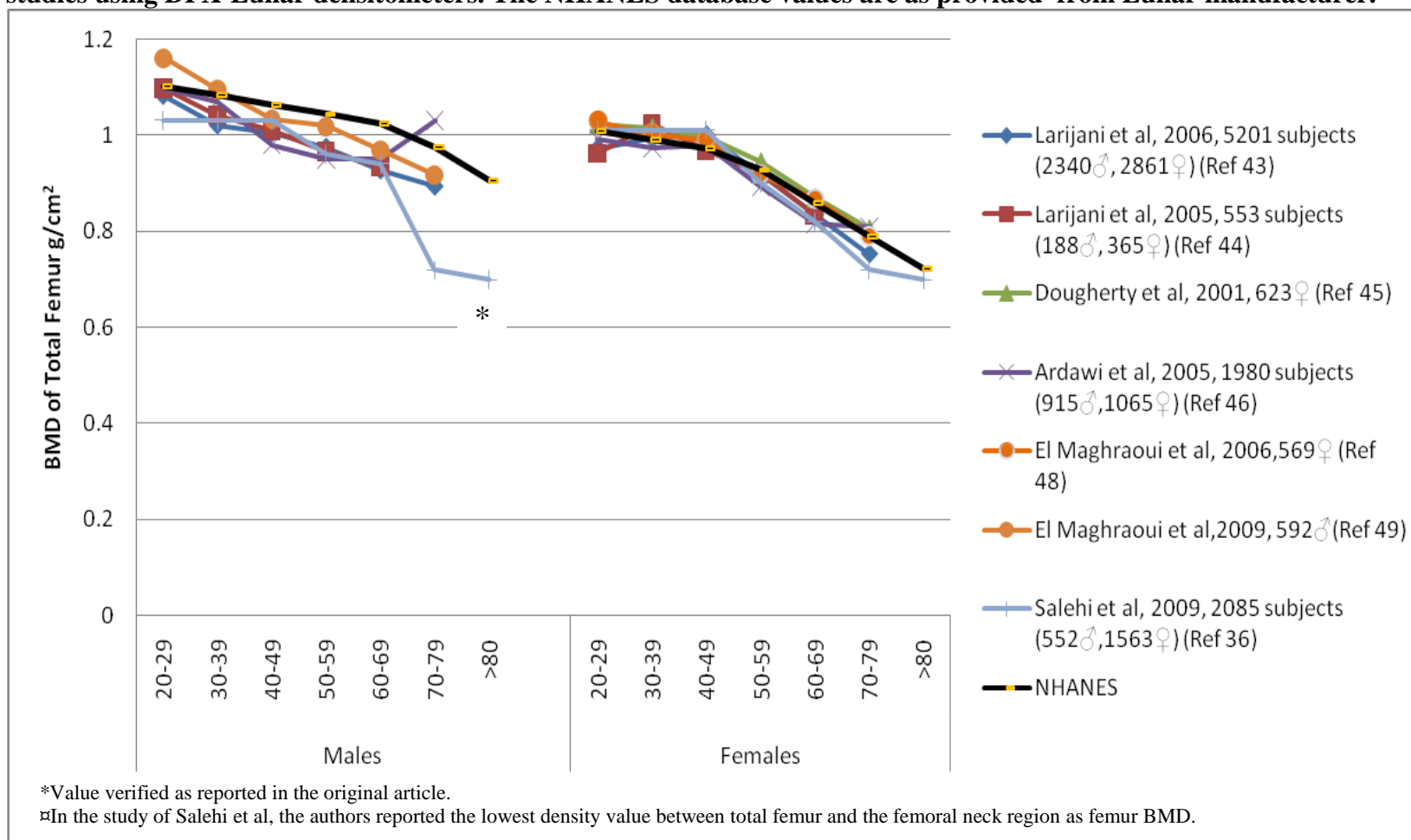
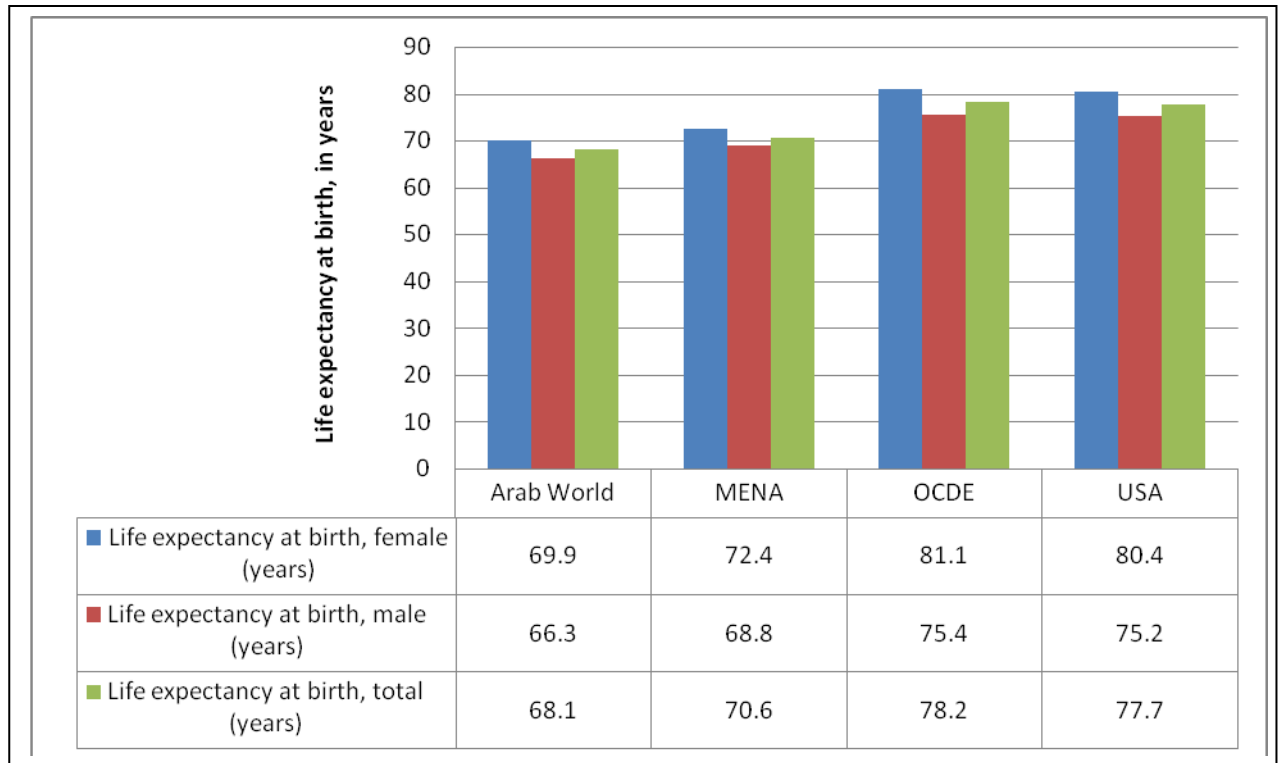


Figure 3: life expectancy at birth in the Arab World, MENA, OCDE and USA



**MENA: Middle East and North Africa**

**OCDE: Organization for Cooperation and Economic development (European Countries)**

**USA: United States of America**

**Table 1: Osteoporosis prevalence in various EMR populations**  
**Osteoporosis is defined as a T-score  $\leq$  -2.5 at any site (Spine, hip or forearm)**

Ref	Country	Database	Study Population	N, (% women) Mean age (SD), Age range	% with OP by DXA any site	
					Women	Men
[35]	Iran	NHANES*	Community-based osteoporosis center	N=4188 (91.9%) Mean age: 53.4(11.8)	27.8 <sup>Δ</sup> [26.4-29.2]	
[36]	Iran	NHANES	Cross-sectional	N=2085 (75%) 50 years and above	36.1 [33.7-38.6]	24.5 [20.9-28.5]
[37]	Turkey	NHANES*	Multicenter study, five big cities	N=724 PM women Mean age: 57.6 (9.6)	30.2 [26.7-33.5]	NA
[38]	Turkey	NHANES*	Retrospective study,	N=1247 (62.8%) 65 years and above	65.0 [61.6-68.3]	45.9 [41.3-50.6]
[39]	Saudi Arabia	NHANES	King Khalid Hospital	N=830, PM women 50-80 years	39.5 [36.2-42.9]	NA
[40]	Saudi Arabia	NHANES*	Simulation approach	PM women 50-70 years	23.0	NA
[41]	Jordan	Spanish Reference	Community based outpatient clinics	N= 400, PM women Mean age: 53(12)	29.6 [25.1-34.2]	NA
[42]	Lebanon	NHANES	Population-based random sample	N= 460, (65%) 65 years and above	33.0 [27.5-38.8]	22.7 [16.2-30.2]

PM: postmenopausal.

\* Presumed to be NHANES or manufacturer's database in view of the high prevalence of osteoporosis.

<sup>Δ</sup>This value is the frequency of osteoporosis diagnosis according to the site of assessment as an aggregate for both genders.

**Table 2: Mean peak BMD ( $\pm$  SD) at the lumbar spine, total hip and femoral neck (FN) in both genders in various EMR populations.**

Country <sup>Ref</sup>	DXA reference dataset	Age Group (year)	Women's peak BMD			Men's peak BMD		
			Spine	Hip*	FN	Spine	Hip	FN
Iran <sup>43</sup>	Lunar 7164, GE Madison, WI, USA	20-36	1.182 $\pm$ 0.127	<b>1.006 <math>\pm</math> 0.126</b>		1.181 $\pm$ 0.153	<b>1.096 <math>\pm</math> 0.159</b>	
Iran <sup>44</sup>	Lunar DPX-MD machine	20-29	1.198 $\pm$ 0.132	<b>0.962 <math>\pm</math> 0.132</b>		1.209 $\pm$ 0.132	<b>1.098 <math>\pm</math> 0.15</b>	
Kuwait <sup>45</sup>	Lunar DPX-IQ (Lunar, Madison)	30-39	1.238 $\pm$ 0.14	<b>1.022 <math>\pm</math> 0.11</b>		NA**	NA**	
Saudi Arabia <sup>46</sup>	Lunar DPX-IQ (Lunar, Madison)	30-39	1.128 $\pm$ 0.11	<b>0.992 <math>\pm</math> 0.17</b>	0.963 $\pm$ 0.16	1.137 $\pm$ 0.09	<b>1.098 <math>\pm</math> 0.19</b>	1.045 $\pm$ 0.20
Morocco <sup>8,49</sup>	Lunar Prodigy Vision, GE	20-29	1.156 $\pm$ 0.12	<b>1.029 <math>\pm</math> 0.11</b>		1.205 $\pm$ 0.15	<b>1.161 <math>\pm</math> 0.16</b>	
Lebanon <sup>52</sup>	Lunar DPX-L	20-29	1.100 $\pm$ 0.13		0.912 $\pm$ 0.10	1.139 $\pm$ 0.13		1.033 $\pm$ 0.14
Lebanon <sup>53</sup>	Lunar DPX-L	20-29	1.180 $\pm$ 0.12	<b>0.97 <math>\pm</math> 0.11</b>		1.18 $\pm$ 0.14	<b>1.07 <math>\pm</math> 0.15</b>	

\*The NHANES total hip BMD mean value (SD) among non-Hispanic whites is 1.101 g/cm<sup>2</sup> (0.144) in males and 1.008 g/cm<sup>2</sup> (0.126) in females within the age group 20-29 years; and 1.082 g/cm<sup>2</sup> (0.144) and 0.990 g/cm<sup>2</sup> (0.126) respectively within the age group 30-39 years.

\*\* NA: Not Available