



International
Osteoporosis
Foundation

FRAX[®] Identifying people at high risk of fracture

WHO Fracture Risk Assessment Tool, a new clinical tool for informed treatment decisions

Authored by **Dr. Eugene McCloskey**





**International
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Foundation**

International Osteoporosis Foundation (IOF)

IOF is an international non-governmental organization, which is a global alliance of patient, medical and research societies, scientists, healthcare professionals and the health industry. IOF works in partnership with its members and other organizations around the world to increase awareness and improve prevention, early diagnosis and treatment of osteoporosis.

Although osteoporosis affects millions of people all over the world, awareness of the disease is still low, doctors often fail to diagnose it, diagnostic equipment is often scarce, or not used to its full potential, and treatment is not always accessible to those who need it to prevent the first fracture. IOF's growing membership has more than doubled since 1999, reflecting the increasing international concern about this serious health problem. There are 193 member societies in 92 locations worldwide (July 2009). IOF member societies represent 5.33 billion people, which is equivalent to 82% of the world's population.

For more information about IOF and to contact an IOF member society in your country please visit: <http://www.iofbonehealth.org>

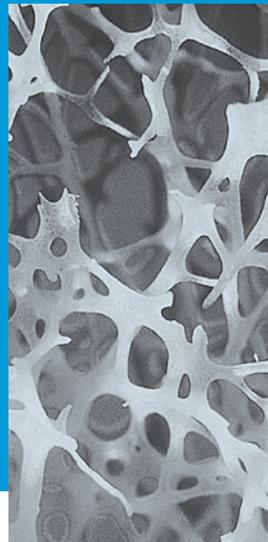
What is osteoporosis?

Osteoporosis is a disease in which the density and quality of bone are reduced, leading to weakness of the skeleton and increased risk of fracture, particularly of the spine, wrist, hip, pelvis and upper arm. Osteoporosis and associated fractures are an important cause of mortality and morbidity.

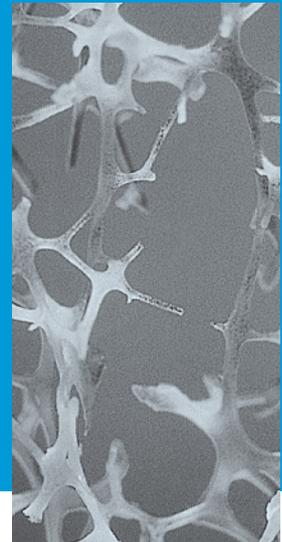
- In women over 45, osteoporosis accounts for more days spent in hospital than many other diseases, including diabetes, myocardial infarction and breast cancer¹.
- It is estimated that only one out of three vertebral fractures come to clinical attention².

1. Kanis JA, Delmas P, Burckhardt P, et al. (1997) Guidelines for diagnosis and management of osteoporosis. The European Foundation for Osteoporosis and Bone Disease. *Osteoporos Int* 7:390-406.

2. Cooper C, Atkinson EJ, O'Fallon WM, et al. (1992) Incidence of clinically diagnosed vertebral fractures: a population-based study in Rochester, Minnesota, 1985-1989. *J Bone Miner Res* 7:221-227.



Normal bone



Osteoporotic bone

Cover photo by **Gilberto Domingues Lontro**

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Foreword

Osteoporosis is often described as the *silent epidemic* as it is a pain-free, symptomless disease in which bone becomes progressively porous, fragile and loses strength. As bone strength decreases the outcome is often broken bones (fractures), even occurring after a minor bump or fall. Unlike the underlying disease, fractures are certainly not silent – they are a major cause of suffering, disability, poor quality of life and premature death. In older persons, there is a significant increase in mortality (death), particularly following a broken hip.

Around the world, one woman in three and one man in five over the age of 50 is affected by osteoporotic fractures resulting in a heavy personal burden and costs to health care services that exceed those of many other major diseases, including heart disease, stroke and breast cancer. In 2000, there were an estimated 9 million new osteoporotic fractures worldwide, of which 1.6 million were at the hip, 1.7 million were at the forearm and 1.4 million were clinical spinal (vertebral) fractures. 51% of these fractures occurred in Europe and the Americas, while most of the remainder occurred in Southeast Asia and the Western Pacific regions. With the increasing number of elderly people in the population, the number of fractures will increase two- to three-fold over the next few decades.

The good news is that much can be done to maintain bone strength and reduce the chances of developing osteoporosis and fractures. Lifestyle changes can improve bone health, for example taking regular exercise, having a balanced diet with sufficient calcium, getting sufficient vitamin D from incidental sunlight exposure, avoiding cigarette smoking and excessive alcohol intake.

As well, there are now several effective therapies that act on the skeleton to reduce fracture risk for individuals at higher risk. Identification of individuals at higher risk has been the subject of much research over the past 20 years and experienced clinicians in the field are well able to appropriately manage the patients who come to their attention.

However, the reality today is that only a relatively small proportion of those at risk have access to timely diagnosis and appropriate care. As a result, despite great advances in diagnostic techniques and therapies, the impact of the burden of fractures on society remains largely unchanged. Even in countries with comparatively sophisticated medical services, the diagnosis and treatment of osteoporosis is often neglected, even for those people who have already suffered a fragility or low trauma fracture.

This neglect arises from the failure of many national governments to regard osteoporosis and the resulting fractures as a major health priority, resulting in a lack of awareness and appreciation among patients about their risk of fracture and a lack of expertise and knowledge amongst many physicians and other health care professionals.

Now with the development of the WHO Fracture Risk Assessment Tool (FRAX[®]) clinicians around the world are able to more easily identify those at greatest risk of fracture. FRAX[®] will be especially useful in those regions where bone density tests are scarce or unavailable.

The FRAX[®] tool is freely available online to all clinicians and health care professionals. IOF supports its widespread use and further development as an important step in making fracture prevention a priority around the world. We hope that this report, which provides a comprehensive overview and outlines possible implementation strategies, will help advance the worldwide use of this important new tool.

Background

Because of its serious consequences, the prevention of osteoporosis and its associated fractures is considered essential to the maintenance of health, quality of life, and independence in the elderly population. In May 1998, the 51st World Health Assembly adopted a resolution requesting the Director-General to formulate a global strategy for the prevention and control of non-communicable diseases including osteoporosis.

Against this background, WHO approved a programme of work within the terms of reference of the WHO Collaborating Centre at Sheffield. The project also had the support of the International Osteoporosis Foundation (IOF), the National Osteoporosis Foundation (USA), the International Society for Clinical Densitometry (ISCD) and the American Society for Bone and Mineral Research (ASBMR). The aims of the programme were to identify and validate (scientifically analyse) clinical risk factors for use in fracture risk assessment on an international basis, either alone, or in combination with bone mineral density (BMD) tests.

Osteoporosis is such a common disease that it must be managed largely at a primary care level. Therefore, a further aim was to develop algorithms for risk assessment that were sufficiently flexible to be used in the context of many primary care settings, including those where BMD testing was not readily available. The WHO Fracture Risk Assessment Tool, known as the FRAX[®] tool (<http://www.shef.ac.uk/FRAX>), is the product of this programme.

Table 1

The aim of the clinician in managing osteoporosis

- to reduce the risk of fractures
- to identify patients at increased risk of fracture
- to assess that risk accurately
- to improve the patient's perception of that risk
- to give advice to aid understanding of the disease, the aims of therapy and the choice of therapy
- treatment
 - lifestyle advice
 - therapeutic agents



One of the primary aims of the clinician is to reduce the risk of fractures through the identification and assessment of those patients who are at increased risk.

Predicting fracture risk – the development of FRAX[®]

The ability to assess skeletal strength by the use of x-ray based techniques such as dual energy x-ray absorptiometry (DXA) led the WHO to define osteoporosis in terms of bone mineral density in 1994. The WHO-defined T-score of ≤ 2.5 Standard Deviation (SD) is frequently used as both a diagnostic and intervention threshold, and bone mineral density testing has provided the main approach to assessing fracture risk. While a proven technique, there are several problems with the use of BMD tests alone in the assessment of fracture risk. The principal difficulty is that BMD alone has low sensitivity, so that the majority of osteoporotic fractures will occur in individuals with BMD values above the osteoporosis threshold, typically in the osteopenic range (T-score of less than -1 and greater than -2.5 SD). (see Figure 1)

In the past 15 years, a great deal of research has taken place to identify factors other than BMD that contribute to fracture risk. Examples include age, sex, a prior fracture, a family history of fracture, and lifestyle risk factors such as physical inactivity and smoking. Some of these risk factors are partially or wholly independent of BMD (i.e. they provide information on fracture risk above that of BMD alone) and the combined use of such risk factors could enhance the information provided by BMD alone. Conversely, some strong BMD-dependent risk factors can, in principle, be used for fracture risk assessment in the absence of BMD tests. For this reason, the consideration of well-validated risk factors, with or without BMD, is likely to improve

WHO definitions based on bone mineral density levels*

Normal

BMD is within +1 or -1 SD of the young adult mean

Osteopenia (low bone mass)

BMD is between -1 and -2.5 SD below the young adult mean

Osteoporosis

BMD is -2.5 SD or more from the young adult mean

Severe (established) osteoporosis

BMD is more than -2.5 SD and one or more osteoporotic fractures have occurred

*based on DXA measurement at hip, spine or forearm

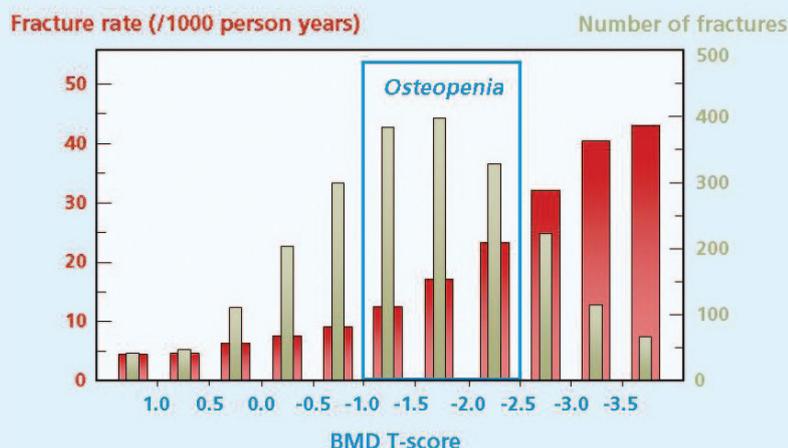
NOTE For every standard deviation (SD) below peak bone mineral density, fracture risk increases by 50-100%. The same BMD values are provisionally used for men because currently there is little data on BMD and fracture in men.

fracture prediction and the selection of the most appropriate individuals for treatment.

Working with many leading investigators across the globe, the WHO Collaborating Centre collated information on fracture risk factors from 12 prospectively studied population-based cohorts (groups) in diverse geographic territories using the primary individual data. The cohorts included centres in Europe (the multicentre EVOS and EPIDOS studies and single centre studies in Rotterdam, Kuopio, Lyon, Gothenburg and Sheffield), North America (the CaMos study and Rochester, USA), Australia (the DOES study) and Japan (Hiroshima). The cohort participants had a baseline assessment documenting clinical risk factors for fracture and approximately 75% also had BMD measured at the hip. The follow-up was approximately 250 000 patient-years in 60 000 men and women during which more than 5000 fractures were recorded. This unique dataset allowed the examination of several individual risk factors for fracture and their inter-relationships with other risk variables, notably age and BMD.

Figure 1

Osteoporotic fractures and Bone Mineral Density (BMD)



BMD is a strong predictor of fracture risk. However, the majority of fractures occur in women with BMD above the osteoporosis threshold, typically in the osteopenic range (Siris et al, 2001).

What is risk and how to measure it

For many clinical risk factors, epidemiological studies commonly report the risk ratio or relative risk (RR). This simply expresses the risk of an event, such as fracture, in individuals who have the risk factor compared to those without the risk factor. Clinicians working within a particular field of medicine feel at ease with this approach – for example, they widely acknowledge that a prior fracture doubles the risk of future fracture compared to those without prior fracture. A problem arises, however, when one asks the question “*doubles it from what?*” as this implies that we know the absolute risk of fracture in those without prior fracture.

This last point is very difficult to determine at a population level, whereas the average risk of fracture in the whole age-matched population is somewhat easier to obtain in many countries, at least for hip fracture. The argu-

ment is the same for other outcomes such as mortality (death). Whereas it is difficult to obtain good mortality data in sub-groups of the population, even smokers for example, it is relatively straightforward to get average mortality statistics for the whole population. The metric to consider therefore is not relative risk but population relative risk (PRR) where the risk of an individual is compared with the whole population of the same age and sex.

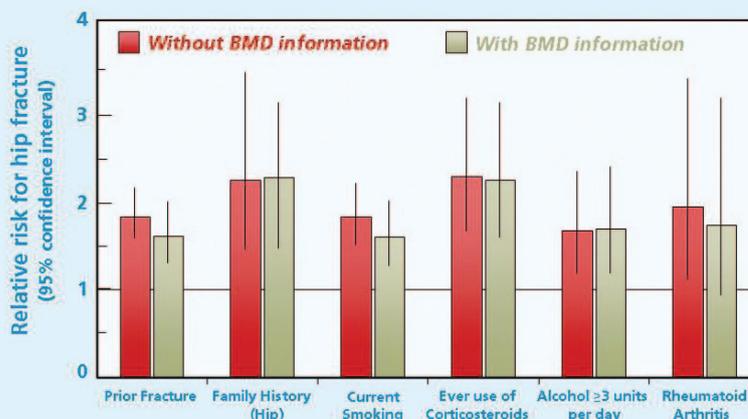
The metric to consider therefore is not relative risk but population relative risk (PRR) where the risk of an individual is compared with the whole population of the same age and sex.

A similar approach can be applied to continuous factors such as BMD. The use of a single metric such as PRR enables the combination of risk factors with appropriate adjustment for the interactions they have with each other. If the chosen risk factors are totally independent of each other, the combination is particularly powerful in estimating risk.

The risk factors shown in this figure and used by FRAX[®] are significant contributors to osteoporotic fracture risk, over and above that provided by BMD and age. The different contribution of these risk factors is taken into account in the 10-year fracture probabilities in FRAX[®].

Figure 2

FRAX[®] makes use of independent risk factors



Accessing FRAX[®]

The FRAX[®] tool is openly available to all at the University of Sheffield website (<http://www.shef.ac.uk/FRAX>). As well as being available for the countries previously outlined, the website is available in several languages (English, Chinese, French, German, Italian, Japanese and Spanish) independently of the country model chosen. Several new language versions will be available in the near future. The website also gives more details about the risk factors used and includes a frequently asked questions section and access to downloadable documents describing the background and development of FRAX[®].

In addition to the web version, several handheld calculators are being developed in both paper and electronic formats. An important development will be the incorporation of FRAX[®] into the software of the various DXA scanners so that a simultaneous calculation can be carried out at the time of measurement of femoral neck BMD. Future developments will also include the ability to run FRAX[®] as a stand-alone application on computers not connected to the internet. It is also being incorporated into several primary care patient management programmes.

Risk factors incorporated into FRAX®

In the final FRAX® model, the risk of fracture is calculated in men or women from age, body mass index (BMI) computed from height and weight and independent risk variables comprising; a prior fragility fracture, parental history of hip fracture, current tobacco smoking, ever long-term use of oral glucocorticoids, rheumatoid arthritis, other causes of secondary osteoporosis and daily alcohol consumption of 3 or more units daily.

Femoral neck (hip) BMD can additionally be entered, preferably as a T-score. It is important to note that in both male and female patients, the T-score should be derived using the NHANES III database for female Caucasians aged 20-29 years.

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The large sample used in the development of FRAX® permitted the examination of the relationship of each risk factor with age, sex, duration of follow up and, for continuous variables (BMD and BMI) the relationship of risk with the variable itself, in a way previously not possible. For example, in a meta-analysis of femoral neck BMD published by Marshall and colleagues in 1996, the gradient of risk for hip fracture for each 1SD decrease in

Table 2

Information required to calculate a patient's 10-year probability of fracture

- country
- bone mineral density
- age
- gender
- clinical risk factors
 - low body mass index
 - previous fragility fracture
 - parental history of hip fracture
 - glucocorticoid treatment
 - current smoking
 - alcohol intake (3 or more units per day)
 - rheumatoid arthritis
 - other secondary causes of osteoporosis



Figure 3

FRAX® calculation tool - UK

Country : UK Name / ID : About the risk factors ⓘ

Questionnaire:

1. Age (between 40-90 years) or Date of birth
Age: Date of birth: Y: M: D:

2. Sex Male Female

3. Weight (kg)

4. Height (cm)

5. Previous fracture No Yes

6. Parent fractured hip No Yes

7. Current smoking No Yes

8. Glucocorticoids No Yes

9. Rheumatoid arthritis No Yes

10. Secondary osteoporosis No Yes

11. Alcohol 3 or more units per day No Yes

12. Femoral neck BMD (g/cm²)
Select DXA

BMI: 23.9

The ten year probability of fracture (%)

without BMD

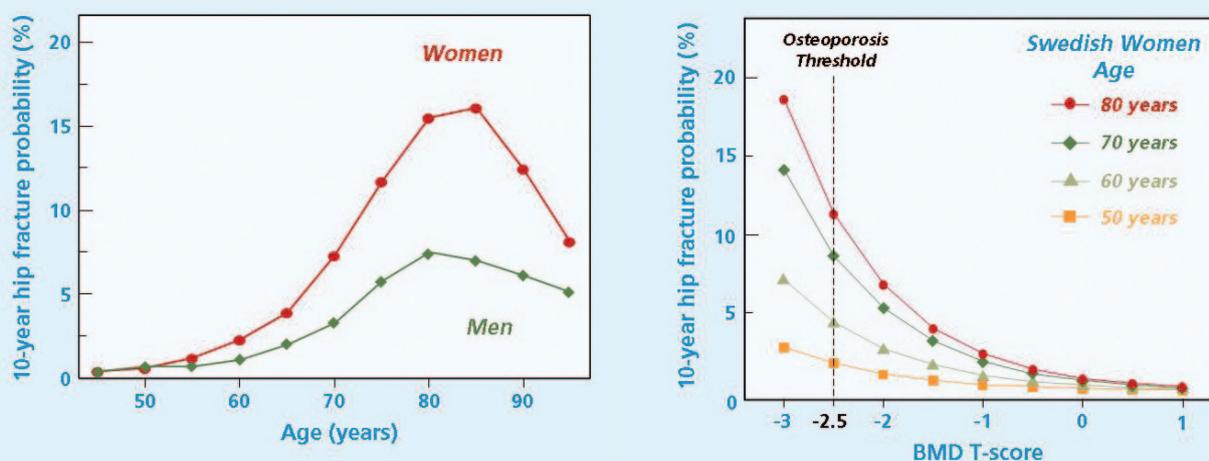
Major osteoporotic	9.5
Hip fracture	1.5

The FRAX® tool gives immediate calculation of the 10-year probability of a major fracture (clinical spine, wrist, proximal humerus and hip) or hip fracture alone with or without the addition of BMD measured at the femoral neck.

Figure 4

Fracture probability is age, BMD and gender specific

Instead of applying the same relative risk for a decrease in BMD across all ages, the FRAX[®] tool allows a more individualised calculation to be made that takes account of the BMD and its interaction with age.



femoral neck BMD was 2.6. This is an average gradient of risk and there is quite a marked interaction between age and the gradient of risk with substantially higher gradients being observed at younger ages. This allows the impact of measured BMD to be tailored more to an individual patient with different gradients being used in the prediction for a 50 year old than that used at the age of 85 years.

The performance of FRAX[®] has been evaluated in eleven independent cohorts from Europe, North America, Australia and Japan that did not participate in the development of the model, demonstrating that the FRAX[®] tool is widely applicable. Further validation is ongoing in other studies of men and in ethnic groups not covered to date.



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Calculating the probability of fracture in the next 10 years – absolute risk rather than relative risk

We know that certain factors increase risk, but the question of *increases it from what and to what?* remains key, as it is the absolute risk of a fracture that will influence decisions. An example of the difference between relative risk and absolute risk can be seen in the purchase of National Lottery tickets in the UK. If an individual buys 5 tickets instead of 1, the relative risk of winning is 5 i.e. they are 5 times more likely to win which looks an attractive proposition. However, the absolute risk or chance of winning, though improved, will be 1 in just under 3 million, an exceedingly unlikely event! The knowledge of absolute risk is important for physicians and healthcare providers to allow them to develop intervention thresholds. It is equally important for patients as the knowledge of the level of risk is useful in altering lifestyle and adhering to prescribed treatments.

The calculation of absolute risk requires knowledge of the incidence of fracture and death in populations across a range of ages and for both men and women. A unique attribute of FRAX® compared to other fracture prediction tools is that it also examines the interaction between the risk factors and mortality.

A similar approach has been adopted in other disease areas, most notably in the assessment of cardiovascular risk, where the simultaneous consideration of smoking, blood pressure, diabetes and serum cholesterol permits the identification of patients at high risk in the next 5-10 years. The use of absolute fracture risk is applicable to both sexes, all ages, all races and all countries even though the incidence of osteoporotic fractures varies widely by age, sex, ethnicity and geography.

The calculation of absolute risk requires knowledge of the incidence of fracture and death in populations across a range of ages and for both men and women. This is because the probability of fracture depends to some extent on an individual's risk of dying – when the risk of death is high, as at very old ages, the probability of fracture actually decreases (see Figure 4). A unique attribute of FRAX® compared to other fracture prediction tools is that it also examines the interaction between the risk factors and mortality. For example, it incorporates the impact of risk factors, such as smoking or low BMI, on both fracture and death risk. Life expectancy and fracture risk varies enormously in different regions of the world, so that the FRAX® models need to be calibrated to the known epidemiology of fracture and death.



Rheumatoid arthritis carries a fracture risk over and above that provided by BMD

Table 3

Country specific FRAX® models	
■ Very high risk	Austria, Belgium, Sweden, Switzerland
■ High risk	Argentina, China (Hong Kong), Finland, Germany, Italy, China (Taiwan), UK, United States (Caucasian)
■ Moderate risk	France, Japan, Spain, New Zealand, US (Hispanic), US (Asian)
■ Low risk	China, Lebanon, Turkey, US (Black)

At present FRAX® models are available for the countries shown (left) according to categories of risk (10-year probability of hip fracture in women aged 65 years with no clinical risk factors). Other models are being developed. In the absence of a model for a particular country, a surrogate country should be chosen, based on the likelihood that it is representative of the index country.

FRAX[®] country-specific models

In the current FRAX[®] model (version 3.0, July 2009; <http://www.shef.ac.uk/FRAX>), models are available for the countries shown in Table 1 and the variability of 10-year fracture probabilities across some of these countries is shown in Figure 5.

The need to select the appropriate country model should be emphasised. In the absence of a FRAX[®] model for a particular country, a surrogate country should be chosen, based on the likelihood that it is representative of the index country in terms of life expectancy and fracture incidence. FRAX[®] will continue to develop and expand with new countries being added once adequate epidemiological data on fractures, particularly hip fractures, are collected or updated.

Ethnicity also has a marked effect on the likelihood of fracture. Currently, this is reflected in the FRAX[®] models for the US where epidemiological information on fracture and mortality are available within the Asian, Black, Caucasian and Hispanic communities. When sufficient new epidemiological evidence is available, further models for the same or other ethnic groups, but in different regions will be incorporated into FRAX[®].

Incorporating FRAX[®] into clinical practice – the setting of assessment and intervention thresholds

The importance of identifying such higher risk individuals is shown in Table 4. A widely used measure is the ‘number needed to treat’ (NNT) to prevent a fracture. For example, if a treatment reduces the incidence of vertebral fracture from 10% to 5% during the conduct of a trial, then 5 fractures are saved for each 100 patients treated, which gives an NNT of 20. The lower the NNT, the greater the success of the treatment.

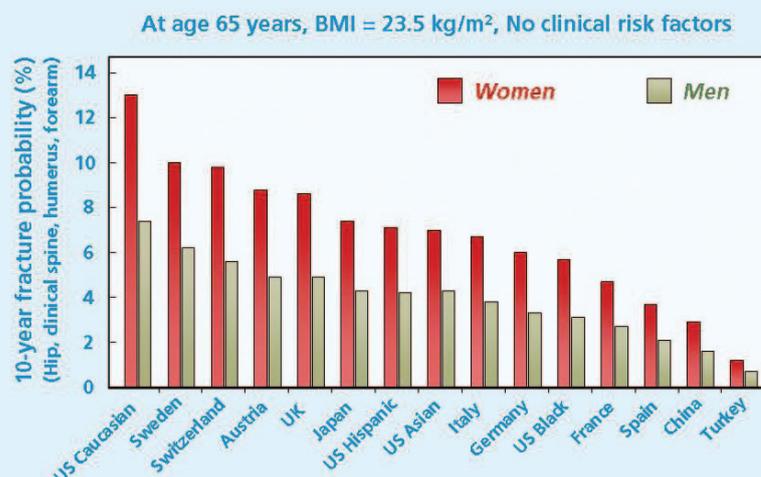
It is important to define intervention and assessment thresholds on a country-by-country basis.

The incorporation of FRAX[®] into clinical practice to identify patients at high risk and to inform treatment decisions is comparable to the approach widely used in the management of coronary heart disease. Access to BMD measurement varies widely and a simple management schema to accommodate healthcare systems with variable access to BMD can be proposed as shown in Figure 6. The size of the

FRAX[®] incorporates the epidemiology of each country to give country-specific rates for major fractures and hip fractures (shown). This suggests that intervention thresholds will also differ widely across countries.

Figure 5

Fracture rates for men and women at age 65 in different countries



intermediate group in Figure 6 in whom a BMD test would be recommended will vary by region and country.

In countries with no access to DXA, the intermediate group would not exist, whereas it will be more substantial in countries with some but limited access. This demands a consideration of the fracture probability at which to undertake BMD testing (assessment thresholds) as well as thresholds for treatment (an intervention threshold). In those countries where DXA is so widely available that screening can be recommended (e.g. in women at the age of 65 years or older in the US) the intermediate group will include the majority of women and only intervention thresholds will be required.

Broadly speaking, two approaches have been suggested to date for the establishment of assessment and/or intervention thresholds. In the US, the intervention thresholds have largely been based on cost-effectiveness analyses (<http://www.nof.org>). In Europe, intervention thresholds have also been estimated for Austria, Germany, Spain, Sweden and the UK using a cost-effectiveness analysis to determine the hip fracture probability at which intervention with a bisphosphonate becomes cost-effective. However, the setting of assessment and intervention thresholds in the UK has reflected a pragmatic updating of existing guidelines supported by, but not solely driven by, cost-effectiveness analyses.

Neither approach may be directly applicable to other countries since the 10-year probability of fracture varies markedly in different countries. Intervention thresholds would also change with differences in costs, particularly fracture costs, which vary markedly worldwide. There is also the issue of affordability or willingness to pay for a strategy. For all these reasons, it is important to define intervention

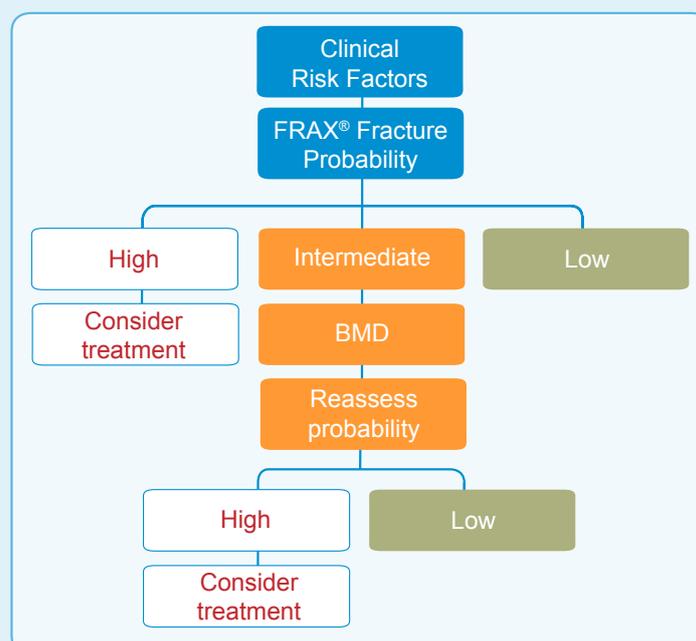
Table 4

<ul style="list-style-type: none"> The number needed to treat (NNT) to prevent a fracture according to baseline fracture risk assuming an efficacy for intervention of 40%. 			
Fracture Risk (%)	Effect of treatment	Fractures saved	NNT
0	0	0	∞
5	3	2	50
10	6	4	25
20	12	8	13
40	24	16	6
80	48	32	3

and assessment thresholds on a country by country basis that takes into account the setting for service provision and willingness to pay, as well as considerations of absolute costs. Management strategies need to be placed in an appropriate health economic perspective for guideline development and for reimbursement and recent reviews have reported the rapid expansion of research on the cost-utility of interventions in osteoporosis. These analyses suggest that cost-effective scenarios can be found in the context of the management of osteoporosis for all but the most expensive interventions. As expected, cost-effectiveness improves at any age with increasing fracture probability, because of the higher risk of fracture and thus the greater number of fractures avoided. Such observations illustrate the important effect of combining independent risk indicators to identify higher risk individuals.

Figure 6

Suggested role of FRAX® in the assessment of fracture risk



Adapted from Kanis, WHO Technical Report, 2008

Limitations of the current FRAX[®] model

While FRAX[®] is a well validated tool, there are always a number of limitations that need to be kept in mind by clinicians using the tool. For example, several of the clinical risk factors identified do not take account of dose-response, but give risk ratios for an average dose or exposure. Alcohol consumption and the use of glucocorticoids (steroids) are good examples. There is good evidence that the risk associated with excess alcohol consumption and the use of glucocorticoids is greater at higher doses and requires clinical judgement to be applied. Additionally, the risk of fracture increases progressively with the number of prior fractures – while of obvious importance, this limitation should easily be over-ridden by clinical judgement as there is little need for a computer algorithm to inform the decision to treat a patient with a history of several fractures.

At present the FRAX[®] tool limits BMD to that measured at the femoral neck as there is a wealth of data available for this skeletal site. It has the advantage that for any given age and BMD, the fracture risk is approximately the same in men and women. Because of this, the T-score is derived from a single reference standard (the NHANES III database for female Caucasians aged 20-29 years) as widely recommended. There are, however, other bone measurements that provide information on fracture risk, and it is hoped that they could be incorporated into FRAX[®]-like risk models when they are more adequately developed.

Provision is made for the inclusion of many secondary causes of osteoporosis. A distinction is made between rheumatoid arthritis and other secondary causes. Rheumatoid arthritis carries a fracture risk over and above that provided by BMD. Whereas this may hold true for



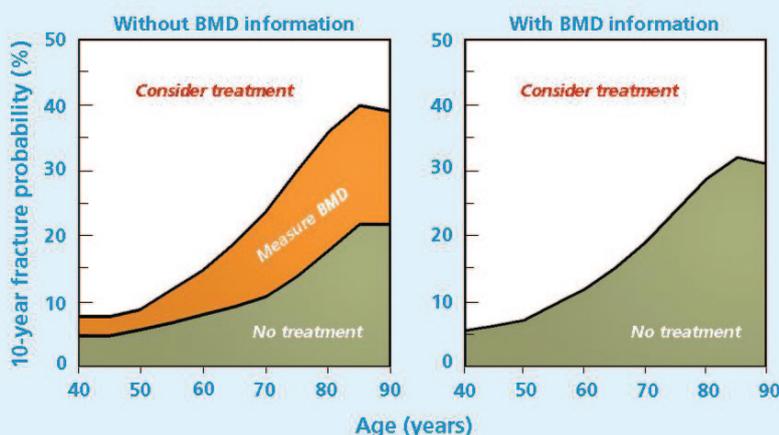
The current version of FRAX[®] does not incorporate fall-related risk factors, even though falls are known to be a strong risk factor

other secondary causes of osteoporosis, the evidence base is weak. For this reason, the other secondary causes of osteoporosis are conservatively assumed to mediate fracture risk as a result of low BMD so that when BMD is entered into the FRAX[®] equations, no further weight is accorded by these other secondary causes.

Finally, the current version of FRAX[®] does not incorporate fall-related risk factors, even though falls are known to be a strong risk factor. It is therefore important to appreciate that fracture risk may be underestimated to some extent in the presence of a falls history.

Figure 7

Management of osteoporosis based on fracture probabilities



Through its use of clinical risk factors alone or in combination with BMD, FRAX[®] serves to enhance the physician's clinical judgement and assessment of the patient.

The UK strategy

In contrast to the recommendation in the US that BMD measurements should be taken in all women aged 65 years and over, at present there is no universally accepted policy for population screening in Europe and other parts of the world, to identify patients with osteoporosis or those at high risk of fracture. Rather, patients are identified *opportunistically* using a case-finding strategy on the detection of a previous fragility fracture or the presence of significant risk factors. The appreciation that clinical risk factors and age modulate risk, and therefore cost-effectiveness, reinforces the view that treatment should be directed on the basis of fracture probability, rather than on a single BMD threshold. In the UK, a management strategy has been proposed by the National Osteoporosis Guideline Group (NOGG) (<http://www.shef.ac.uk/NOGG>) that revised intervention thresholds based on the existing Royal College of Physicians (RCP) strategy, but expressed as fracture probabilities.

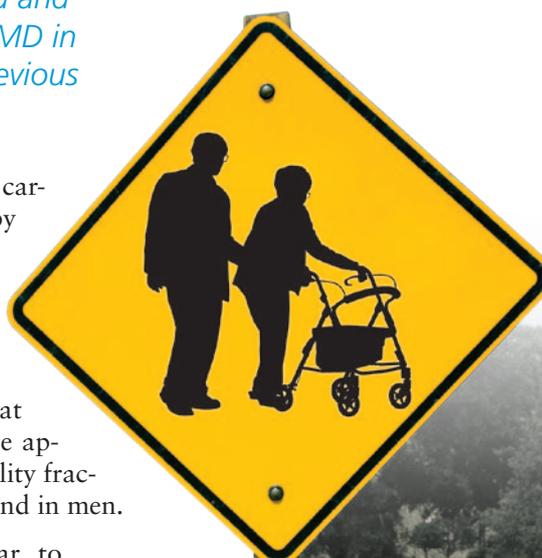
opause with no clinical risk factors who should largely be reassured and who, by definition, would not enter a case-finding strategy.

The size of the intermediate category in Figure 6 in the UK is largely determined by the two assertions carried forward from the RCP guidance. For operational purposes, the strategy has been translated into graphs such as those shown in Figure 7 with an automatic transfer of data between the FRAX® and NOGG websites – this can be observed by using the UK calculation tool at the FRAX® website (see Figure 3) and clicking on the NOGG button that appears with the calculation of probabilities. If fully implemented, the guideline would advocate treatment in approximately 1 in 4 women aged 50-54 years rising to 1 in 2 women aged 75-79 years. It is important to note that the guideline is based on a clinical rationale rather than being driven by cost-effectiveness. The strategy is, however, underpinned by a cost-effectiveness analysis that demonstrates that risk factor combinations resulting in 10-year major fracture probabilities of greater than 7-8% fall below a threshold of £20,000 (Quality Adjusted Life Years) with alendronate costed at £90 per annum. A similar approach to threshold setting could easily be implemented for other country models.

One of the most important recommendations is that treatment can be considered and recommended in the absence of BMD in postmenopausal women with a previous fragility fracture.

The two most important assertions carried forward from the RCP guidance by NOGG are a) the recommendation of a case finding strategy, and b) that treatment can be considered and recommended in the absence of BMD in postmenopausal women with a previous fragility fracture. It recognises that BMD measurement may sometimes be appropriate in the presence of prior fragility fracture, particularly in younger women and in men.

The management pathway is similar to that shown in Figure 6. It begins with the assessment of fracture probability and the categorisation of fracture risk on the basis of clinical risk factors, combined with age, sex and BMI, in an individual with one or more risk factors including a low BMI defined as a value of $\leq 19\text{kg/m}^2$. Following this assessment of fracture probability, some patients at high risk may be offered treatment without recourse to BMD testing as recommended in both the RCP and European guidelines. Many clinicians would perform a BMD test, but frequently this is for reasons other than to decide on intervention e.g. to monitor treatment response. There will be other instances where the probability will be so low that a decision not to treat can be made without BMD. An example might be the healthy woman at men-



FRAX[®] in the clinical setting

The risk of fracture determined by FRAX[®] can be used by the clinician in deciding the next steps. For example, based on NOGG guidelines in the UK:

- If the risk of fracture is low, lifestyle advice about diet and exercise is given but medication is not required.
- If the risk is high then the clinician would likely recommend treatment.
- If the risk is intermediate, then a DXA scan is usually indicated. The FRAX[®] risk is then recalculated and the decision made on whether medication is needed.

Women who have already had a fracture after the menopause may be offered treatment without the need to calculate their risk.

NOGG National Osteoporosis Guideline Group (UK)

NOF National Osteoporosis Foundation (US)

Female, age 67, German

Weight 65kg, Height 162cm (BMI 24.8)

FN BMD T-score -2.5 (osteoporosis)
No other clinical risk factors

10 year fracture probabilities (%)
Major osteoporotic fractures = 10%
Hip fracture = 3.4%

NOGG recommendations for the UK equivalent

Lifestyle advice and reassure

NOF recommendations for the US equivalent

Treat patient



Female, age 55, Chinese

Weight 58kg, Height 165cm (BMI 21.3)

FN BMD T-score -1.9 (osteopenia)
Previous low trauma fracture
On oral glucocorticoid treatment
Diagnosed with rheumatoid arthritis

10 year fracture probabilities (%)
Major osteoporotic fractures = 11%
Hip fracture = 3.0%

NOGG recommendations for the UK equivalent

Treat patient

NOF recommendations for the US equivalent

Treat patient (based on hip fracture probability)



Male, age 66, Italian

Weight 80kg, Height 180cm (BMI 24.7)

Parental history of hip fracture
Current tobacco smoker
Drinks 3 or more units of alcohol per day

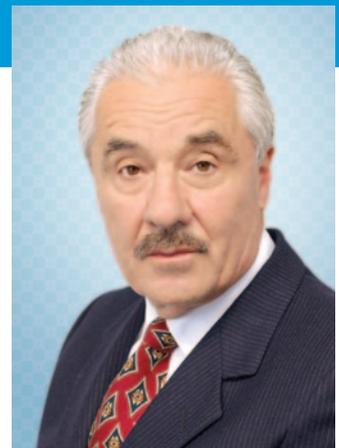
10 year fracture probabilities (%)
Major osteoporotic fractures = 9.3%
Hip fracture = 2.9%

NOGG recommendations for the UK equivalent

Measure BMD, reassess fracture risk

NOF recommendations for the US equivalent

Measure BMD, reassess fracture risk



Summary

The assessment of fracture risk underpins all management strategies to tackle the growing problem of osteoporotic fractures.

The FRAX® tool provides this assessment within the primary care setting and is equally accessible by patients. It can play a major role in both targeting treatment appropriately and in education about osteoporosis, the risk factors and bone health in general. Rather than a gold standard, FRAX® should be considered as a platform technology which will continue to build as new validated risk indicators and new country specific models become available.

Notwithstanding, the present model provides an aid to enhance patient assessment by the integration of clinical risk factors alone and/or in combination with BMD.

Using FRAX® in your country

National osteoporosis societies can further the use of FRAX® where appropriate, in their countries:

- Work with physicians associations to inform them about FRAX®, using the FRAX® educational slide kit available on the IOF website.
- Update national guidelines for the management of osteoporosis to include use of FRAX® for informed clinical decision-making.
- Consult the guidelines of organizations like NOGG, the NOF, or ESCEO as examples of how FRAX® can be integrated into national guidelines. These documents are available on the IOF website at <http://www.iofbonehealth.org/health-professionals/national-regional-guidelines/evidence-based-guidelines.html>

Glossary

<i>SD</i>	Standard deviation
<i>T-score</i>	The number of standard deviations below or above the mean for young healthy adults of the same sex
<i>Validated</i>	Supported by scientific research
<i>Cohort</i>	Group in the population
<i>Metric</i>	Defined standard of a measurement
<i>RR</i>	Relative risk <i>Ratio of the probabilities of an event occurring in an exposed group versus a non-exposed group</i>
<i>PRR</i>	Population relative risk <i>The risk of an individual is relative to an age- and sex-matched segment of the population, as opposed to the whole population</i>
<i>AR</i>	Absolute risk <i>The actual numerical probability of an event occurring within a predefined time period</i>
<i>GR</i>	Gradient of risk <i>The increase in fracture risk per unit change of a risk factor (for example, BMD)</i>
<i>EVOS</i>	European Vertebral Osteoporosis Study
<i>EPIDOS</i>	Epidemiology de l'osteoporose
<i>CaMos</i>	Canadian Multicentre Osteoporosis Study
<i>DOES</i>	Dubbo Osteoporosis Epidemiology Study

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As a major advance in the assessment of fracture risk, FRAX® will help clinicians around the world to identify those people who are most in need of treatment



Professor John Kanis
IOF President



A new clinical tool for informed treatment decisions

The FRAX® tool has been developed to evaluate fracture risk of patients. It is based on individual patient models that integrate the risks associated with clinical risk factors, with or without bone mineral density (BMD) at the femoral neck.

The FRAX® models have been developed from studying population-based cohorts (groups) from Europe, North America, Asia and Australia. In its most sophisticated form, the FRAX® tool is computer-driven. Several simplified paper versions, based on the number of risk factors are also available, and can be downloaded from the FRAX® website for office use (<http://www.shef.ac.uk/FRAX/>).

The FRAX® algorithms give a 10-year probability of hip fracture and the 10-year probability of a major osteoporotic fracture (clinical spine, forearm, hip or shoulder fracture).

www.iofbonehealth.org

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