A FRAX model for the estimation of osteoporotic fracture probability in Portugal

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RESUMO

Introdução: O objetivo deste trabalho é desenvolver uma versão Portuguesa da ferramenta FRAX® que estima o risco individual de fratura nos dez anos subsequentes à avaliação.

Métodos: Todos os casos de fratura da anca ocorridos aos 40 ou mais anos foram extraídos da base nacional de altas hospitalares no período compreendido entre 2006 e 2010. A taxa de mortalidade e estimativas populacionais foram obtidas através do Instituto Português de Estatística. As incidências foram calculadas para cada género e ano, em intervalos de cinco anos e foi esta a média considerada na análise. Dados sobre outras fraturas major foram imputadas a partir da epidemiologia da Suécia, à semelhança da maioria dos modelos FRAX® já disponíveis. Todos os procedimentos metodológicos e resultados foram submetidos à avaliação crítica do grupo de peritos nacionais e representantes das diferentes sociedades científicas e associações de doentes, direta ou indiretamente envolvidos na osteoporose.

Resultados: A incidência de fracturas da anca é superior nas mulheres, aumentando com a idade. A menor incidência foi observada na faixa etária dos 40-44 anos (14,1 e 4,0 por 100.000 habitantes para homens e mulheres, respectivamente). A maior incidência foi observada entre os 95-100 anos (2.577,6 e 3.551,8/100.000 para homens e mulheres, respectivamente). A probabilidade de fratura osteoporótica major ou fratura da anca a dez anos aumenta com a diminuição do T-score e com o aumento da idade.

Conclusão: Portugal tem uma das menores incidências de fraturas entre os países europeus. A ferramenta FRAX® foi calibrada com sucesso para a população Portuguesa, e pode agora ser utilizada para estimar a probabilidade a 10 anos de fratura no nosso país. Todas as entidades com interesse na osteoporose aprovaram a metodologia utilizada no modelo Português do FRAX®

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Palavras-chave: Probabilidade a 10 anos fratura; FRAX; Fraturas da anca; Fratura Osteoporótica; Portugal.

ABSTRACT

Introduction: The objective of this study was to develop a Portuguese version of the fracture risk assessment tool FRAX®, which estimates the individual's risk of fracture over the ten subsequent years.
Methods: All cases of hip fracture occurred at or after 40 years of age were extracted from the Portuguese National Hospital Discharge Register from 2006 to 2010. Age and sex-ranked population estimates and mortality rates were obtained from National Statistics. Age- and gender stratified incidences were computed and the average of the five years under consideration was taken. Rates for other major fractures were imputed from the epidemiology of Sweden, as undertaken for most national FRAX® models. All methodological aspects and results were submitted to critical appraisal by a wide panel of national experts and representatives of the different stakeholders, including patients.
Results: Hip fracture incidence rates were higher in women than in men and increased with age. The lowest incidence was observed in 40-44 years group (14.1 and 4.0 per 100,000 inhabitants for men and women, respectively). The highest rate was observed among the 95-100 age-group (2,577.6 and 3,551.8/100,000 inhabitants, for men and women, respectively). The estimated ten-year probability for major osteoporotic fracture or hip fracture increased with decreasing T-score and with increasing age. **Conclusions:** Portugal has one of the lowest fracture incidences among European countries. The FRAX® tool has been successfully calibrated to the Portuguese population, and can now be used to estimate the ten-year risk of osteoporotic fractures in this country. All major stakeholders officially endorsed the Portuguese FRAX® model and co-authored this paper.

Keywords: 10-year fracture probability; FRAX; Hip fracture; Osteoporotic fracture; Portugal.

INTRODUCTION

Osteoporosis is a serious worldwide epidemic. In the year 2000 around 9.0 million osteoporotic fractures occurred of which 1.6 million were at the hip, 1.7 million at the forearm and 1.4 million were clinical vertebral fractures[1]. It is estimated that 8000 to 10,000 osteoporotic hip fractures occur in Portugal each year[2,3]. According to the available data it is estimated that 10 to 20% of these patients die within one year and 50% become unable to walk without support and therefore institutionalized or dependent on others for simple personal care[3]. Over and above this should be added the morbidity and mortality from osteoporotic fractures at other sites (spine, forearm, humerus, ribs)[4]. This extraordinary burden underlines the importance of identifying individuals and populations at higher risk of fracture so that preventive measures can be targeted effectively.

With this purpose, the University of Sheffield developed a fracture risk assessment tool, named FRAX[5]. FRAX is a computer-based algorithm (http://www.shef.ac.uk/FRAX) that provides an estimate of fracture probability in men and women over the subsequent ten years, based on clinical risk factors (CRFs) with or without the inclusion of bone mineral density (BMD) measured at the femoral neck[5,6]. The identification of the significant CRFs for osteoporotic fracture was supported by a series of meta-analyses. Data from 9 prospective primary cohorts were analysed and the results were validated in 11 other prospective cohorts. These cohorts included more than 275,000 persons corresponding to 1.4 million person-years with more than 22,711 reported fractures[7]. Clinical risk factors identified as relevant included, a prior fragility fracture[8], age and sex[9], body mass index[10], prior use of glucocorticoids[11], secondary osteoporosis[12], rheumatoid arthritis[12], a parental history of hip fracture[13], current cigarette smoking[14], and alcohol intake of 3 or more units/day[15]. The FRAX tool provides a 10-year probability estimate for osteoporotic hip fracture and for major osteoporotic fractures. The latter metric represents a composite of hip, clinical spine, proximal humerus and forearm fractures. The probability estimate takes account of, not only the fracture risk, but also the risk of death in a given individual[6].

Since osteoporotic fracture rates vary greatly between countries, the FRAX algorithm is calibrated to the target population[16]. A total of 50 country and/or ethnic models are currently available[17] and several others are being developed. The relative impact of the various clinical risk factors included in FRAX is assumed to be similar in different countries[18].

Ideally, the country-specific calibration of osteoporotic fracture rates would be based on country-specific incidence data for hip and for each of the other osteoporotic fractures that are considered. However, it is not usually possible to obtain accurate data on non–hip fractures, because many of these do not result in hospitalization or do not require surgery, and so escape to the national hospital discharge registries. This difficulty, common to most countries, has been overcome by imputing non–hip fracture rates based on the gender- and age-specific ratio of hip to non–hip fractures observed in a prospective population-based study performed in Malmo, Sweden[19,10]. This imputation method has been used in the development of several FRAX models[5] and appears to be valid for West European countries, Australia and USA[20].

The aim of the present study was to describe the epidemiology of osteoporotic hip fractures in the Portuguese population and its application to the development of the Portuguese FRAX model. We discuss the underlying assumptions and limitations of this model and present the process that allowed its nationwide endorsement.

METHODS

STEERING COMMITTEE

This project was funded by the Portuguese Government through the Direcção Geral da Saúde – DGS (Portuguese Health Directorate) after a proposal presented by Associação Nacional Contra a Osteoporose – APOROS (National Association Against Osteoporosis) and by an unrestricted grant from Amgen. The principal investigator (JAPS) invited a number of national experts on osteoporosis and representatives of all the relevant Portuguese scientific societies and patient associations to form a Steering Committee, the role of which was to discuss and decide by consensus or majority vote on all relevant aspects of the methodology and results and to seek official endorsement from their organizations to the final model. This work was done through three rounds of e-mail communication and a formal meeting. This paper represents the final consensus endorsed by all individuals and societies involved. The data were collected and analysed by a research nurse (A Marques) with the assistance of an expert in our national discharge registry (A Mota). The organizations and individual experts represented in the panel are given in the authors' affiliation list.

DATA SOURCES, TIME SPAN AND GEOGRAPHICAL AREA

For the calibration of FRAX, we used two different sources of data: (1) the National Hospital Discharge Register maintained by the Administração Central dos Serviços de Saúde - ACSS (Central Administration of Health Service) and (2) the national resident population and mortality statistics, provided by the Instituto Nacional de Estatística – INE (Portuguese Statistics Institute).

The National Hospital Discharge Register provides high quality information and the ACSS, responsible for its maintenance, guarantees that over 99% of all hospital admissions are registered by properly trained medical staff. The database is submitted to regular quality checks which have met international quality standards at European and global levels for at least ten years. For the purpose of this report, the steering panel decided to include data for the 5 years from 2006 to 2010.

The same quality standards are not provided in the Madeira and Azores autonomous regions, since the accuracy of the register cannot be audited. According to INE, Madeira and Azores had 493.379 inhabitants compared to 10.636.979 in mainland Portugal in 2010. The steering panel decided, therefore, to exclude data from these regions and to limit the analysis to mainland Portugal.

The Portuguese National Hospital Discharge Register does not report admissions to emergency care without hospitalization. This led the steering committee to consider that data from the registry on non-hip osteoporotic fractures were not reliable, as most of these fractures do not require hospitalization. The panel recognized that it would be impossible to obtain reliable data on those fractures and thus accepted that the imputation from Malmo would be applied as previously described[6].

The Portuguese National Hospital Discharge Register is limited to the National Health Service and does not include admissions to private hospitals. There are no statistics related to these hospitals. In Portugal, access to the national health-care service is universal and almost free of charge for all the population from all social groups and all ages. Private hospitals have only recently gained significant usage and the panel estimated that, due to the high costs involved, only a small minority of osteoporotic hip fractures would have been treated outside public hospitals, thus escaping the database we used. By majority vote, the panel decided

that the National Hospital Discharge Register was a valid representation of the epidemiology of osteoporotic hip fractures for the Portuguese mainland population.

The annual age and sex distribution of the Portuguese population was provided by the Portuguese INE (http://www.ine.pt) up until the age of 85 years. For age groups above 85 years, population data was calculated from The Human Mortality Database (http://www.mortality.org) provided by the same Institute.

Mortality data were obtained from Portuguese Instituto Nacional de Estatística (http://www.ine.pt) for the years 2006 to 2010.

FRACTURES INCLUDED

The Portuguese National Hospital Discharge Register uses the ICD-9-CM for coding and this has remained the same over the time interval under study. We transposed the codes requested by WHO in ICD-10 to ICD-9. The correspondence was submitted to consensus with experts in coding and in Orthopaedics within the steering panel. Using the electronic National Registry of Hospitalized Persons containing patient hospital discharge notes, all patients were identified with the corresponding ICD-9 codes of proximal femur fracture: 820.02, 820.03, 820.08, 820.09, 820.10, 820.11, 820.12, 820.13, 820.21, 820.31 (ICD10: S72.0 femoral neck fracture), 820.22, 820.32 (ICD10: S72.1 pertrochanteric fracture), and 820.22, 820.32 (ICD10: S72.2 subtrochanteric fracture). By a majority vote, we did not exclude high-energy fractures, even though our register would allow these to be identified since the frequency of fractures following high energy trauma was higher in patients with osteoporosis than those without osteoporosis[21]. The number of hip fractures under the above mentioned codes reportedly associated with high-energy trauma represented 2.3% of all hip fractures over the 5 years under study. Fractures associated with malignancy and repeat admissions of same patient for a similar fracture within the period under study were excluded.

CALCULATION OF FRACTURE INCIDENCE RATES

The rates of hospitalization for hip fracture for each gender and age-group (5-year intervals) above 40 years of age, were computed for each calendar year from the number of hospital admissions and resident population, and expressed as cases per 100,000. There was no age-specific time trend in incidence seen from 2006 to 2010 (p=0.24) in men (HR= 0.96; 95% confidence interval = 0.85-1.09) or women (HR=1.04; 95% CI= 0.97-1.12). For this reason, the annual incidence for the five-year period was calculated as the mean of the five yearly incidence rates for each age group and gender. Similar calculations were done for mortality.

CALIBRATION

The development and validation of FRAX have been extensively described[6, 20, 22]. The computation of fracture probability integrates the risk of death and the risk of fracture and takes into account several clinical risk factors with demonstrated effects on the fracture hazard and, where found, the risk of death. Calculations can be performed with or without the inclusion of BMD at the femoral neck.

Poisson models were used to calculate the hazard functions of fracture and death. Age-and gender-specific fracture and mortality hazards were computed. The relationship between the hazard functions was used to calculate the 10-year probability of fracture for a combination of given risk factors[4, 18]. The independent contribution of each risk factor was used to compute probabilities of fracture in the absence of clinical risk factors or in the presence of any combination[5].

The relative impact of each clinical risk factor and T-score is assumed to be the same in all populations. Therefore, risks estimated by different country-specific FRAX models should have a similar impact of all clinical risk factors, the differences being a translation solely of the background incidence of fracture and the mortality of the index population. The Steering Panel accepted this assumption, but advised that its validity should be evaluated in our population.

RESULTS

The age (5 year age intervals) and gender-specific annual incidence rates for hip fracture in the Portuguese population are presented in Table I. The rate of hip fractures was very consistent over the five-year interval under appreciation, as demonstrated by the small range around the average. Hip fracture rates in men and women showed a similar age-dependent increase. Hip fractures were rare prior to age 65 years but then increased sharply in both sexes. Men had higher hip fracture rates than women prior to age 59 years, after which women had substantially higher hip fracture incidences. Mortality rates (Table I) showed, as expected, an increase with age. Men had

TABLE I. AGE- AND GENDER-SPECIFIC HIP FRACTURE INCIDENCES AND MORTALITY IN THE PORTUGUESE MAINLAND POPULATION. NUMBERS REPRESENT THE AVERAGE OF THE FIVE ANNUAL INCIDENCES CALCULATED FOR EACH YEAR OF THE TIME INTERVAL 2006-2010. NUMBERS IN BRACKETS REPRESENT THE MINIMUM AND MAXIMUM ANNUAL INCIDENCES FOR EACH AGE-GROUP AND GENDER IN INDIVIDUAL CALENDAR YEARS FROM 2006-2010

Age category (years)	Average annual hip fracture incidence per 100,000 inhabitants, 2006-2010 (range)		Average annual mortality rate per 100,000 inhabitants, 2006-2010	
	Male	Female	Male	Female
40-44	14.1 (12.2-14.9)	4.0 (3.2-5.3)	278	113.0
45-49	18.4 (15.4-21.4)	6.9 (6.3-7.7)	416	171.0
50-54	22.3 (19.5-25.7)	15.4 (14.7-16.3)	608	239.8
55-59	31.6 (26.8-34.1)	29.6 (27.3-33.2)	822	338.6
60-64	45.1 (37.6-48.8)	60.6 (57.3-63.1)	1192	504.6
65-69	75.9 (67.3-81.3)	117 (110-128)	1819	829.0
70-74	129 (122-134)	274 (270-281)	2983	1507.0
75-79	264 (238-281)	609 (572-625)	5148	2913.2
80-84	535 (502-570)	1190 (1147-1218)	9279	6080.2
85-89	1006 (900-1099)	2291 (1997-2495)	13217	11098
90-94	1663 (1502-1772)	2989 (2704-3395)	17422	16206
95-99	2578 (2310- 2938)	3552 (3198-3958)	19452	19101

TABLE II. ESTIMATED 10-YEAR PROBABILITY (%) OF MAJOR OSTEOPOROTIC AND HIP FRACTURE FOR A 75-YEAR-OLD PORTUGUESE MAN OR WOMAN WITH A BMI OF 24 KG/M² AND A PARENTAL HISTORY OF HIP FRACTURE ACCORDING TO THE T-SCORE OF FEMORAL NECK BMD

T-Score	Men		Women	
	Major osteoporotic fracture	Hip fracture	Major osteoporotic fracture	Hip fracture
Not taken into account	9.7	7.0	19	13
1	3.5	1.4	4.8	0.9
0	5.1	2.7	6.8	2.2
-1	7.9	5.3	10	5
-2	14	11	17	11
-3	23	20	32	25
-4	38	35	55	49

Data from www.shef.ac.uk/frax

higher age-specific mortality than women across the age spectrum.

Data presented in Table I was used to calibrate the Portuguese version of FRAX. An example of the integration of these hazards is shown in Table II which shows the effect of BMD on the 10-year probabilities of major osteoporotic and hip fracture in Portuguese men and women aged 75 years with a BMI of 24 kg/m^2 and a parental history of hip fracture. Fracture risk estimates increased with decreasing T-score. At any given BMD, women had a higher 10-year probability of major osteoporotic fracture than men. The 10-year probability of hip fracture was higher in women than in men with these clinical risk factors, except for a T-score equal or higher than -1 SD, when the reverse was observed. Table III, shows the 10-year probabilities of osteoporotic fractures for Portuguese men and women by age and gender in the absence or presence of at least

TABLE III. 10-YEAR PROBABILITIES (PERCENT) OF OSTEOPOROTIC FRACTURE IN ABSENCE OR PRESENCE OF EACH CLINICAL RISK FACTOR, WITHOUT INFORMATION ON BMD BY AGE (YEARS (Y)) AND SEX. BMI IS SET AT 24KG/M²

	Men					Women				
Clinical risk factor	50y	60y	70y	80y	90y	50y	60y	70y	80y	90y
No risk factor	1.2	1.8	3.3	6.5	7.9	1.5	2.8	6.4	15	17
Previous fracture	2.6	3.8	6.4	11	12	3.4	5.9	12	23	27
Parental hip fracture	2.4	3.4	5.5	14	19	3.0	5.3	11	29	34
Current smoking	1.3	1.9	3.6	7.0	8.4	1.6	3.1	7.3	16	18
Glucocorticoid use[a]	2.0	2.9	5.1	9.4	11	2.5	4.7	11	22	24
Rheumatoid arthritis	1.6	2.5	4.8	9.9	12	2.1	3.9	9.3	21	25
Secondary osteoporosis[b]	1.6	2.5	4.8	9.9	12	2.1	3.9	9.3	21	25
Alcohol use[c]	1.5	2.2	4.2	8.7	11	1.9	3.5	8.2	19	23

Data from www.shef.ac.uk/frax

a. Current exposure to oral glucocorticoids or prior exposure for a period of at least 3 months at a daily dose of at least 5 mg prednisolone (or equivalent doses of other glucocorticoids)

b. Includes patients diagnosed with diabetes mellitus type I, osteogenesis imperfecta, untreated long-standing hyperthyroidism, hypogonadism or premature menopause (<45 years), chronic malnutrition or malabsorption, and chronic liver disease

c. Exposure to at least three units of alcohol daily (one unit equals 8–10 g alcohol)

TABLE IV. ESTIMATED TEN-YEAR RISK ESTIMATES OF HIP AND A MAJOR OSTEOPOROTIC FRACTURES (%) IN MEN AND WOMEN AGED 65, 75, AND 85 YEARS (Y) AT THE THRESHOLD FOR OSTEOPOROSIS (T-SCORE = –2.5 SD), WITH NO CLINICAL RISK FACTORS, IN SELECTED EUROPEAN COUNTRIES (BMI SET TO 24 KG/M²)

	Men						Women					
	Hip Fracture			Major osteoporotic fracture			Hip Fracture			Major osteoporotic fracture		
Country	65y	75y	85y	65y	75y	85y	65y	75y	85y	65y	75y	85y
Portugal	2.4	3.7	4.3	5.0	7.2	7.7	2.1	4.2	6.2	6.0	11	14
Spain	2.0	3.4	3.7	4.5	6.3	7.1	1.7	3.9	5.3	5.4	9.3	13
Italy	3.5	5.0	5.7	7.5	9.5	10	2.9	5.5	7.6	8.6	14	17
UK	3.4	4.0	4.4	9.3	9.1	8.4	2.9	4.8	7.7	12	15	18
Sweden	5.9	8.7	7.3	13	15	13	4.8	9.3	10	15	21	23

Data from www.shef.ac.uk/frax

one single clinical risk factor, when BMD information is not available and with a constant BMI of 24 kg/m². At younger ages, the differences between the two genders were smaller. For example the 10-year probability of osteoporotic fracture was estimated at 1.6% in a 50-year-old female with a BMI of 24 kg/m² and with current smoking as the single clinical risk factor, as compared to 1.3% in a 50-year-old male with a similar clinical risk factor. In the elderly, the differences were larger with the same scenarios but for a woman aged 90 years the 10-year probability of osteoporotic fracture was 18% against 8.4% for 90-year old man. Parental history of hip fracture was the strongest clinical risk factor in the elderly: a 90-year-old woman with a BMI of 24 kg/m², and a parental hip fracture as single clinical risk factor, had a 34% 10-year probability of osteoporotic fracture, whilst the risk was only 17% for a female of equal age and BMI without a parental hip fracture.

Table IV shows fracture risk estimates for males and females at 3 different ages at a T score of -2.5 SD and a BMI of 24 kg/m² for men and women from Portugal and other selected European countries. Ten-year probability estimates for hip and a major osteoporotic fracture for Portugal are slightly higher than for Spain and lower than for Italy but substantially lower than probabilities in the United Kingdom and particularly in Sweden.

DISCUSSION

This article, describes the FRAX model developed for Portugal, which can be used to assess individual 10-year probabilities of hip fracture, as well as of osteoporotic fracture in Portuguese men and women. It has been calibrated to the total population of mainland Portugal, based on nationwide incidence rates for hip fracture and mortality (data 2006-2010) according to the procedure established by the University of Sheffield.

The methodology employed to establish the national incidence of hip fractures is robust and the results are very stable across the years under consideration and their pattern by age and sex consistent with current knowledge on the epidemiology of hip fractures around the world (Table I). These data suggest that ICD coding in the national database was accurate. However we can see higher incidence of hip fractures in males compared to females in the age category 40-59 year. One of the contributions to this finding lies in the inclusion of high-energy fractures. These fractures only represented 2.3% of all hip fractures, and the same methodology has been employed in other national validations of FRAX with similar findings[23-25]. However, this must be acknowleged as a limitation of FRAX Port.

Portugal presents one of the lowest incidences of hip fracture in Europe, very similar to that observed in Spain. This will, obviously, translate into lower 10-year probabilities estimated by FRAX. Apart from hip fracture, most osteoporotic fractures in Portugal are managed in emergency rooms and are not entered into any form of national registry. For this reason, the estimation of major osteoporotic fracture is supported, in our model, on extrapolations from actual data collected in carefully followed up cohorts. This technique has been used in most national models of FRAX and assumes that the ratio of hip/major osteoporotic fractures is similar to that observed in Sweden and similarly affected by certain epidemiological factors such as age and gender.

The incorporation of this FRAX model into daily clinical practice and clinical guidelines for the management of osteoporosis can now be considered in Portugal, as in other countries[17].

Users are advised to take into account the strengths and limitations of FRAX which have been extensively discussed[26,27]. FRAX should not be seen as a precise instrument or a gold standard for patient management, but rather as a reference platform exposed to critical appraisal according to specific patient features[28].

The strengths of the FRAX tool are many and valuable: this is a model based on extensive data from multiple cohorts with and without BMD, which has been extensively validated in additional cohorts[5]. It is adapted to each country, by incorporating the local epidemiology of fracture and mortality. Finally, it is easy to access and applicable to men (aged 50+ years) as well as to postmenopausal women. The FRAX model may also facilitate the communication between patient and clinician in weighing the risks and benefits of starting fracture prevention.

Obviously, the FRAX models may need to be updated from time to time to take account of changing epidemiology and population structure. We are planning to do this if any substantial difference becomes apparent in the Portuguese census 2011, when these data become available.

Some authors criticise FRAX in general for not making use of several important clinical risk factors for fracture. This limitation is due either to the lack of valid data to incorporate that factor in the model (e.g. history of falls) or because of difficulties in their accurate quantitation in a primary care setting (physical activity, vitamin D deficiency, bone turnover markers, or loss of bone mass between sequential BMD measurements)[9,26,29-33]. Also, FRAX does not take into account characteristics of prior fractures such as their number and severity.

FRAX Portugal was not validated for ethnic minorities living in our country. In such cases we can only recommended that the health care practitioner uses good clinical judgment, in that ethnic minorities in Portugal (e.g. Asians and Blacks) will likely have a lower fracture risk as seen in other countries[18, 34]. Conversely, it is probable that the incorporation of data from minorities into the National model will not significantly affect the estimations for the Portuguese Caucasian population as this segment of the population is largely predominant: according to data provided by Portuguese National Institute of Statistics (http://www.ine.pt) in 2008, there were 124,291 individuals born in Africa and 27.814 individuals born in Asia living (legally) in Portugal, representing 1,5% of the total population. Two countries have constructed ethnic specific FRAX models for their ethnic minorities: USA and Singapore[28].

FRAX Port has not been prospectively validated in Portugal. This is a difficult task, which requires care-

ful data collection in large numbers of people that are representative of the general population. Several studies are in progress in Coimbra (SAOL[35-37]), Oporto[38], and other Portuguese prospective cohorts.

The use of FRAX as a clinical tool demands a consideration of intervention thresholds. These should be based on clinical imperatives and consider the cost-effectiveness of possible FRAX-based strategies in the epidemiological, social and economic context of each country[6, 39-42]. Studies on the health and economic impact of different intervention thresholds in Portugal are also underway.

In conclusion, a FRAX tool has been developed to compute fracture probabilities calibrated to the epidemiology of Portugal. The FRAX tool is a major advance in the management of osteoporosis in both postmenopausal women and men aged above 50 years, allowing a multidimensional estimate of the 10-year probability of osteoporotic fracture and, thus, the tailoring of pharmacological interventions to high-risk subjects.

Further studies are necessary to assess the validity of predictions offered by FRAX Port in our population and propose any appropriate adjustments regarding the impact of specific risk factors. Research is also needed at a national level to establish the cost-effectiveness of possible FRAX-based prevention and intervention strategies.

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