

# Race-specific FRAX models are evidence-based and support equitable care

Citation for published version (APA):

Kanis, J. A., Harvey, N. C., Lorentzon, M., Liu, E., Schini, M., Abrahamsen, B., Adachi, J. D., Alokail, M., Borgstrom, F., Bruyère, O., Carey, J. J., Clark, P., Cooper, C., Curtis, E. M., Dennison, E. M., Díaz-Curiel, M., Dimai, H. P., Grigorie, D., Hiligsmann, M., ... Board of IOF, and the IOF Working Group on Epidemiology and Quality of Life (2024). Race-specific FRAX models are evidence-based and support equitable care: a response to the ASBMR Task Force report on Clinical Algorithms for Fracture Risk. *Osteoporosis International*, 35(9), 1487-1496. <https://doi.org/10.1007/s00198-024-07162-w>

## Document status and date:

Published: 01/09/2024

## DOI:

[10.1007/s00198-024-07162-w](https://doi.org/10.1007/s00198-024-07162-w)

## Document Version:

Publisher's PDF, also known as Version of record

## Document license:

Taverne

## Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

## General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.umlib.nl/taverne-license](http://www.umlib.nl/taverne-license)

## Take down policy

If you believe that this document breaches copyright please contact us at:

[repository@maastrichtuniversity.nl](mailto:repository@maastrichtuniversity.nl)

providing details and we will investigate your claim.



# Race-specific FRAX models are evidence-based and support equitable care: a response to the ASBMR Task Force report on Clinical Algorithms for Fracture Risk

John A. Kanis<sup>1,2</sup> · Nicholas C. Harvey<sup>3,4</sup> · Mattias Lorentzon<sup>1,5</sup> · Enwu Liu<sup>1</sup> · Marian Schini<sup>6</sup> · Bo Abrahamsen<sup>7</sup> · Jonathan D. Adachi<sup>8</sup> · Majed Alokail<sup>9</sup> · Fredrik Borgstrom<sup>10</sup> · Olivier Bruyère<sup>11</sup> · John J. Carey<sup>12</sup> · Patricia Clark<sup>13,14</sup> · Cyrus Cooper<sup>3,4,15</sup> · Elizabeth M. Curtis<sup>3</sup> · Elaine M. Dennison<sup>3,16</sup> · Manuel Díaz-Curiel<sup>17</sup> · Hans P. Dimai<sup>18</sup> · Daniel Grigorie<sup>19,20</sup> · Mickael Hiligsmann<sup>21</sup> · Patricia Khashayar<sup>22</sup> · Willem Lems<sup>23</sup> · E. Michael Lewiecki<sup>24</sup> · Roman S. Lorenc<sup>25</sup> · Alexandra Papaioannou<sup>26</sup> · Jean-Yves Reginster<sup>27</sup> · René Rizzoli<sup>28</sup> · Eric Shiroma<sup>29</sup> · Stuart L. Silverman<sup>30</sup> · Eleanor Simonsick<sup>31</sup> · Manuel Sosa-Henríquez<sup>32</sup> · Pawel Szulc<sup>33</sup> · Kate A. Ward<sup>3,34</sup> · Noriko Yoshimura<sup>35</sup> · Helena Johansson<sup>1,5</sup> · Liesbeth Vandenput<sup>1</sup> · Eugene V. McCloskey<sup>2,6,36</sup> · on behalf of the Board of IOF, and the IOF Working Group on Epidemiology and Quality of Life

Received: 4 June 2024 / Accepted: 19 June 2024

© International Osteoporosis Foundation and Bone Health and Osteoporosis Foundation 2024

## Abstract

Task Force on ‘Clinical Algorithms for Fracture Risk’ commissioned by the American Society for Bone and Mineral Research (ASBMR) Professional Practice Committee has recommended that FRAX® models in the US do not include adjustment for race and ethnicity. This position paper finds that an agnostic model would unfairly discriminate against the Black, Asian and Hispanic communities and recommends the retention of ethnic and race-specific FRAX models for the US, preferably with updated data on fracture and death hazards. In contrast, the use of intervention thresholds based on a fixed bone mineral density unfairly discriminates against the Black, Asian and Hispanic communities in the US. This position of the Working Group on Epidemiology and Quality of Life of the International Osteoporosis Foundation (IOF) is endorsed both by the IOF and the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO).

**Keywords** Fracture probability · FRAX adjustment · Race and ethnicity · Racism

The findings of a Task Force on ‘Clinical Algorithms for Fracture Risk’ commissioned by the American Society for Bone and Mineral Research (ASBMR) Professional Practice Committee have recently been published [1]. The aim of the ASBMR Task Force was to determine the impact of race and ethnicity adjustment in the USA Fracture Risk Assessment Tool (FRAX®). This followed a general concern, well-articulated in an editorial by Vyas et al. [2], that clinical assessment algorithms which include race or ethnicity may discriminate against individuals of Black, Asian and minority ethnicity (BAME—also described as the global majority, hereinafter termed non-White which specifically includes Black, Hispanic and Asian communities) [3]. Subsequent publications variously argued that the ethnic-specific FRAX

models do [4] or do not discriminate against the non-White community [5–9] or were agnostic [10, 11]. The conclusions of the Task Force were that there is little justification for estimating fracture risk while incorporating race and ethnicity adjustments and recommended that fracture prediction models do not include adjustment for these attributes.

The Task Force reviewed the extensive evidence for discrimination in the field of osteoporosis and fracture management. The question arises whether racial discrimination in the US is furthered by the ethnic and race-specific FRAX models. For the reasons articulated below, we firmly believe that this is not the case.

Extended author information available on the last page of the article

## Epidemiology

It is well established the Black, Asian and Hispanic communities in the US have a lower hip fracture rate than White communities [11–14]. The task force confirms this in their systematic review [15]; indeed, in the cohorts studied, there were far fewer fractures in Black and Hispanic women than in White women. The lowest fracture rates were observed in the Black community, who, where reported, had rates of hip fracture 70% lower than in White women and rates of major osteoporotic fractures between 49 and 67% lower. African Americans on average also have higher femoral neck bone mineral density (BMD) than White Americans [11, 16, 17], but higher BMD only partly explains the lower fracture risk [18]. For the same BMD, African Americans have a hip fracture probability that is half that of White individuals of the same age and sex [8, 18]. Indeed, differences in BMD between countries vary by approximately 1 SD and cannot account for the greater than tenfold variations in hip fracture rates worldwide [19, 20]. In this context, the statement of the Task Force ‘As demonstrated by the systematic review, .... there is little justification for estimating fracture risk while incorporating race and ethnicity adjustments’ is both illogical and unjustified.

A component of the argument of the Task Force was that despite reasonably good calibration of FRAX according to ethnicity in postmenopausal women aged 50–64 years, FRAX discriminated poorly between women who do and do not experience fracture in the Women’s Health Initiative (WHI). Indeed, the area under the receiver operating characteristic curve (AUC) ranged from 0.53 to 0.57 for a major osteoporotic fracture and from 0.54 to 0.66 for hip fracture [21]. In a further study of WHI in women age 50–79 years, the AUC was higher (0.64 and 0.61 for MOF in White and Black women, respectively, and 0.75 and 0.81 for hip fracture in White and Black women, respectively) [22]. The improvement in AUCs with a wider age range is expected since the AUC will be smaller the narrower the age range that is studied, illustrating but one of the many fallacies in comparing AUCs within and across studies [23]. We have had the opportunity to assess AUCs in Black and White men and women with a near identical age range (68–80 years) in the Aging and Body

Composition (Health ABC) study [24] given in Table 1. The important finding is not so much the absolute value of the AUC but the finding that there is no difference in AUC between Black and White individuals.

It is important to reemphasise that the significance of ethnicity will vary by geography. For example, although Black individuals in the US have on average, lower FRAX 10-year fracture probabilities than White individuals, the probability of fracture in the US Black population is much higher than in African Black populations, in part due to the higher fracture rates and lower mortality risks in those from the US [25]. Ethnically Chinese individuals from Hong Kong, mainland China and Singapore provide a further example of location-specific differences [7]. First-generation immigrants to Sweden (with high fracture rates in Swedes) have an incidence of hip fracture that is markedly lower than that observed in Swedish-born individuals. Although there is a small rise in incidence with time after immigration, the incidence remains much lower [26]. Thus, ratios of fracture incidence between ethnic and racial groups in the US are unlikely to apply elsewhere.

## Inequity of care

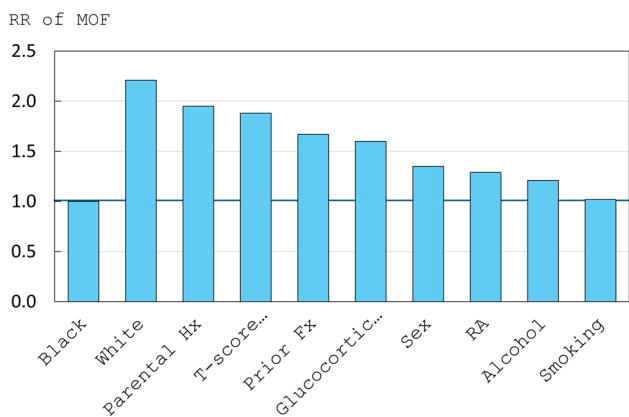
The Task Force rightly notes that there is inequity of care in the non-White community in the US. This is widely documented both generally [27] and in the context of osteoporosis [6, 16, 28], but it is unclear how it would be rectified by risk assessment that did not take ethnicity or race into account. Indeed, the converse is more likely. Because fragility fractures in the US are much less common in the Black than in the White community, the US FRAX calculator returns a lower fracture risk for Black women by a factor of 0.43 compared to that for White women (0.50 for Asian and 0.53 for Hispanic women), consistent with the Task Force findings and those presented in Table 1. These differences are substantial and rank as highly as or greater than the other strong risk factors such as a prior fragility fracture (Fig. 1).

Thus, their omission would decrease the performance characteristics of FRAX by as much as or more than omitting a prior fracture as an input variable. Moreover, in applying the ASBMR approach into clinical care, a large proportion of the non-White community will be exposed to anti-resorptive treatments that are unnecessary, and risk adverse events without clinical gain. An obvious example

**Table 1** Performance of FRAX for incident fractures in the Health ABC study in men and women according to race and ethnicity

	White ( <i>n</i> = 1775)			Black ( <i>n</i> = 1268)		
	Fractures	AUC	95% CI	Fractures	AUC	95% CI
MOF	392	0.700	0.672–0.729	123	0.692	0.645–0.738
Hip fracture	176	0.724	0.684–0.764	58	0.721	0.654–0.787

MOF, major osteoporotic fracture; AUC, area under the receiver operating characteristic curve



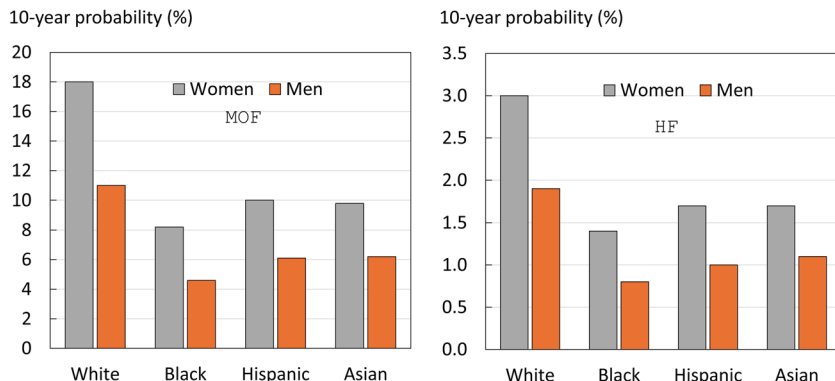
**Fig. 1** Ethnic-specific 10-year probabilities of a major osteoporotic fracture in Black women from the US at age 65 years with a body mass index set at 25 kg/m<sup>2</sup>. The first bar on the left, set at 1, denotes the risk ratio for a major osteoporotic fracture (MOF) with no additional indices of risk. The impacts of additional indices of risk that are used in FRAX are shown in order of weight in subsequent bars. The probability ratio for sex is female/male ratio. RA, rheumatoid arthritis; Prior Fx, prior fracture; Parental Hx, parental history of hip fracture

is the increase in risk of atypical femoral fracture in the Asian community and less clinical gain following exposure to anti-resorptive medication compared with White patients [29–32].

### The wider context

It is instructive to consider other input variables which could be construed as discriminatory. For example, under the Task Force’s logic, future iterations of FRAX may need to be gender-neutral to avoid discrimination by sex. The irony of the *reductio ad absurdum* is that omitting sex from FRAX adjustments would have less impact than the Task Force’s current recommendations to omit ethnicity (see Fig. 1). On average, hip fracture rates are 1.65 higher in women than men [7]. Mean hip fracture rates are 2.33 higher in White than in Black individuals

**Fig. 2** Ethnicity-specific 10-year probabilities of a major osteoporotic fracture in men and women at age 65 years who have had a prior fragility fracture in the US. Body mass index set at 25 kg/m<sup>2</sup>. MOF, major osteoporotic fracture; HF, hip fracture



from the US, as are fracture probabilities (Fig. 2). The difference is such that, on average, White men in the US have a fracture probability that is greater than that of non-White women. In other words, race and ethnicity are more important than sex in improving the accuracy of FRAX and failure to calibrate for ethnicity would have adverse consequences greater than failure to consider sex in fracture risk assessment.

### FRAX is the wrong ASBMR target

The appeal of personalised absolute probability-based assessment is that treatments can be applied in an equitable manner that is neither sexist nor racist. For example, treatment is commonly recommended in the US in women with osteopenia when the 10-year probability of a major osteoporotic fracture exceeds 20% or that for hip fracture exceeds 3% [33]. Thus, the same probability threshold is applied irrespective of race and ethnicity or age. Similarly, in the case of ethnicity-specific models in Singapore, a single threshold is applied to all ethnicities [34, 35]. In many countries, particularly within Europe, Eurasia, the Middle East and Latin America [36–39], intervention thresholds are based on a fracture probability that is equivalent to a woman with a prior fragility fracture since treatment is widely recommended in women with a prior fragility fracture [40]. The logic is applied irrespective of sex.

Prior fracture apart, FRAX is the principal gateway for risk assessment in many countries; in others, including the US, bone mineral density (BMD) is most usually the primary access route [40]. Treatment is recommended in postmenopausal women where the T-score is –2.5 or lower, FRAX being reserved for those with a T-score between –1 and –2.5 (osteopenia) [33]. With the use of a T-score threshold, non-White individuals will be treated at a much lower risk than White individuals with less benefit and a higher risk–benefit profile. The effect is not trivial. For example, White women at age 65 years from the US with a femoral neck T-score of –2.5 (no other risk factors and body mass index of 25 kg/m<sup>2</sup>) have a 10-year probability of a major

osteoporotic fracture of 18%. Black women of the same profile have a probability of only 7.5%. No single additional clinical risk factor would redress the disparity but a T-score of  $-4.4$  would.

Similarly, if one accepts the notion of equity for intervention thresholds based on probability, then the BMD threshold is in fact discriminatory by race and ethnicity. For example, if the intervention threshold is set at 20%, then the equivalent T-score at age 65 years is  $-2.8$  for White women but  $-3.7$  for Asian women,  $-3.8$  for Hispanic women and  $-4.2$  for Black women [7]. Thus, the use of FRAX generating an individualised absolute probability as a gateway for intervention helps to resolve, rather than exacerbate, current ethnic/racial inequalities. Where appropriate information exists, other countries have opted to take advantage of race- and ethnic-specific models (Brunei, Malaysia, Singapore and South Africa) [34, 41–43].

## Considering ethnicity

It has been argued that even if race or ethnicity does associate with clinical outcomes, this does not necessarily justify its inclusion in diagnostic or predictive tools [2]. The rationale is that most adjustments assume that genetic difference tracks reliably with ethnicity and race. While the aspiration that consideration of genetic architectures might replace the need for race or ethnicity is worthy [44], its potential contribution to osteoporosis management is presently limited [45] and restricted to only a small component of fracture risk (bone mineral density) [46–48]. The counter argument is that risk factors should be chosen according to established criteria irrespective of our understanding of their basis or their accuracy [7]. A good example is consumption of alcohol, which is notorious for being inaccurately reported. In general, people who drink alcohol tend to underestimate their alcohol consumption [49, 50]. It matters not whether the return is accurate—only that it provides a consistent indication of risk, which it does [51]. Thus, we are more interested in association than causality, and in consistency of input variable ascertainment between generation of the tool and use of that tool in clinical practice. The same considerations clearly also apply to race, geographic location and ethnicity.

## Considering FRAX

FRAX is a computer-based algorithm (<http://www.shef.ac.uk/FRAX> and <http://www.fraxplus.org>) developed by the then World Health Organization Collaborating Centre for Metabolic Bone Diseases at Sheffield, UK, and first released in 2008. The algorithm, intended for use in primary care, calculates fracture probability from easily obtained clinical risk factors (CRFs) in men and women [52, 53]. The output

of FRAX is the 10-year probability of a major osteoporotic fracture (hip, clinical spine, humerus or wrist fracture) and the 10-year probability of hip fracture. Fracture probability varies markedly in different regions of the world [20]. Thus, the FRAX models need to be calibrated to those countries where the epidemiology of fracture and death is known. Models are currently available for 85 countries across the world. The performance of FRAX can be assessed by the increase in risk of fracture per SD unit increase in risk score. The use of CRFs in conjunction with BMD and age improves the sensitivity of fracture prediction without adversely affecting specificity. At the age of 70 years, for example, the risk of hip fracture increases by 1.84 (95% CI 1.65–2.05) for each SD change in risk score when BMD is not entered. The gradient of risk increases to 2.91 (2.56–3.31) when BMD is included [54]. Overall, the predictive value of FRAX compares favourably with other risk engines such as the Gail score for breast cancer [55].

Notwithstanding, FRAX is far from perfect. Since FRAX is calibrated using national or regional estimates of fracture and death rates, it is axiomatic that FRAX is only as good as the source epidemiology. In this regard, we agree with the ASBMR Task Force that updated representative information is required on the incidence of fracture and death in all ethnicities including American Indians and those of mixed race and ethnicity who are not included in the current iteration of FRAX [13]. Nevertheless, since its launch in 2008, FRAX has proven to be well calibrated in diverse populations from Canada, Israel, Japan, Norway, Taiwan, the UK and US [56–63]. In the recent ASBMR review, analysis of calibration (expressed as observed/expected ratios) reported that FRAX (without BMD) modestly overestimated hip fracture probabilities but that the ethnicity and race-adjusted ratios were similar for different race and ethnicity groups (range mostly 0.8–0.9) [15]. What is not fully explored is whether the clinical risk factors that are input into FRAX have the same weight in racial/ethnic subgroups in the US. The available evidence suggests that this is likely to be the case. Thus, a prior fragility fracture, a given BMD or a history of falls has a similar significance on fracture risk in the White as in the non-White community [8, 64, 65].

While appreciated for its simplicity, an important limitation of FRAX is that several of the input variables do not account for degree of exposure, such as the increase in fracture risk with increasing dose and duration of oral glucocorticoids, the recency and number of prior fractures and magnitude of tobacco and alcohol exposure [66]. Concerns regarding the lack of provision for lumbar spine BMD (commonly recommended in treatment guidelines) and the absence of measurements of the material or structural properties of bone have also been highlighted. To address some of these limitations, a number of exploratory analyses have been conducted in population cohorts



to examine the impact of factors outside of those included in FRAX, with access to these adjustments now being provided via the FRAXplus web-based platform ([www.fraxplus.org](http://www.fraxplus.org)) [52]. These additions are expected to further improve fracture risk assessment whereas deletions such as adjustments for race and ethnicity will have the opposite effect.

## Conclusions and next steps

We agree that race and ethnicity discrimination in the US (and elsewhere) make this an important issue to address. In their editorial, Vyas et al. [2] proposed three questions that should be asked regarding clinical algorithms that include race and ethnicity: ‘Is the need for race correction based on robust evidence and statistical analyses? Is there a plausible causal mechanism for the racial difference that justifies the race correction? And would implementing this race correction relieve or exacerbate health inequities?’ As outlined above, the answer in the case of FRAX favours race and ethnicity responsive models for all three questions. We consider that the lower probability of fracture in the non-White community appropriately reflects the well-documented lower fracture hazards in non-White individuals compared with White individuals. As noted by the Agency for Healthcare Research and Quality, intentional consideration of race to reduce disparities can be beneficial [67] and as echoed by the British Medical Journal, the thoughtful use of race and ethnicity can help identify and address health inequalities [68]. A single race-agnostic FRAX model for the US would decrease the performance characteristics of FRAX by at least as much as omitting a prior fracture as an input variable. Is it equitable to use a knowingly inaccurate calculator? Moreover, it would disadvantage the non-White community who would consequently be exposed to unnecessary treatments, some with adverse events. This is a view also endorsed by the International Osteoporosis Foundation [7] and now by its Working Group on Epidemiology and Quality of Life and by the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO).

We are informed that the FRAX team is always willing to respond to requests to update FRAX models and has done so frequently, usually as a result of updated fracture epidemiology. On the assumption that the Task Force recommendations are accepted by the ASBMR, if other stakeholders in the US including the Bone Health and Osteoporosis Foundation, the Endocrine Society, Menopause Society and the American Association of Clinical Endocrinologists were of the same mind as the ASBMR Task Force, then the FRAX team would reluctantly accommodate the request.

**Acknowledgements** We are grateful to the Board of the International Osteoporosis Foundation (IOF) and the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO) for their endorsement of this position paper.

The Epidemiology and Quality of Life Working Group comprises: Bo Abrahamsen, JD Adachi, Fredrik Borgstrom, Olivier Bruyère, John J Carey, Patricia Clark, Cyrus Cooper, Elizabeth Curtis, Elaine Dennison, Manuel Diaz-Curiel, Hans P Dimai, Celia L Gregson, Daniel Grigorie, Nicholas C Harvey, Mickael Hilgsmann, Helena Johansson, John A Kanis (chair), Patricia Khashayar, Edith Lau, Willem Lems, E Michael Lewiecki, Roman S Lorenc, Paul Lips, Mattias Lorentzon, Eugene V McCloskey, Sergio Ortolani, Alexandra Papaioannou, Jean-Yves Reginster, Stuart Silverman, Manuel Sosa Henríquez, Pawel Szulc, Kate Ward and Noriko Yoshimura.

The Board of the IOF comprise Nicholas C Harvey (President), Cyrus Cooper, Bess Dawson-Hughes, Famida Jiwa, John A Kanis, Eugene V McCloskey, Jean-Yves Reginster, Rene Rizzoli and the following regional representatives:

Africa	Teréza Hough (South Africa) Abdellah El Maghraoui (Morocco) Ngozi Rosemary Njeze (Nigeria) Leith Zakraoui (Tunisia)
Asia-Pacific	Manju Chandran (Singapore) Peter Ebeling (Australia) Ambrish Mithal (India) Atsushi Suzuki (Japan)
Europe	Maria Luisa Brandi (Italy) Olivier Bruyère (Belgium) Nicholas Harvey (UK), IOF President Radmila Matijevic (Serbia)
Latin America	Claudia Campusano (Chile) Patricia Clark (Mexico) Osvaldo Daniel Messina (Argentina) Jorge Luis Alberto Morales Torres (Mexico)
Middle-East	Nizar Abdulateef (Iraq) Bagher Larjani (Iran) Basel K Masri (Jordan) Youssef Saleh (Saudi Arabia)
North America	Bess Dawson-Hughes (USA) Michael McClung (USA) Daniel Pinto (USA) Stuart L Silverman (USA)

## Declarations

**Ethics approval and consent to participate** This position paper contains no original data or personal information and thus issues of ethics, informed consent, and patient confidentiality do not apply.

**Conflict of interest** JA Kanis led the team that developed FRAX as director of the WHO Collaborating Centre for Metabolic Bone Diseases at Sheffield; he is a director of Osteoporosis Research Ltd that maintains FRAX. EV McCloskey, M Lorentzon, NC Harvey, M Schini, E Liu, L Vandenput and H Johansson are members of the FRAX team. JA Kanis, NC Harvey and EV McCloskey are members of the advisory body to the National Osteoporosis Guideline Group. B Abrahamsen has received consultancy/lecture fees/institutional grant funding from UCB, Amgen, Pharmacosmos, Kyowa-Kirin and Gedeon-Richter outside the current work. Olivier Bruyère has received consulting or lecture fees from Amgen, Aptissen, Biophytis, IBSA, Mylan, Novartis, Nutricia, Orifarm, Sanofi, UCB and Viatrix outside the current work. JJ Carey is funded by the Health Research Board of Ireland and has received consultancy/lecture fees/grant funding and honoraria from Ab-

bvie, Amgen, Eli-Lilly, Pfizer, Consilient Health and UCB, all outside the presented work.

M Diaz-Curiel has received consultancy/lecture fees, from Amgen, Takeda, Mereo and Kaiowa-Kirin.

HP Dimai has received consultancy/lecture fees/grant funding/honoraria from Amgen, Braincon, Daiichi-Sankyo, Eli Lilly, Gedeon Richter, Medtronic, Merck Sharp & Dohme, Novartis, Nycomed, Servier, Sinapharm, UCB.

NC Harvey has received consultancy/lecture fees/honoraria/grant funding from Alliance for Better Bone Health, Amgen, MSD, Eli Lilly, Radius Health, Servier, Shire, UCB, Kyowa Kirin, Consilient Healthcare, Theramex and Internis Pharma.

Willem Lems has received speaker fees/consultancy fees from Amgen, UCB, Pfizer and Galapagos (all outside this manuscript).

EM Lewiecki has received consultancy/lecture fees/honoraria/grant funding from Amgen, Radius Health, Kyowa Kirin, Ultragenyx, Ascendis and Angitia.

M Lorentzon has received lecture fees from Amgen, Lilly, Meda, Renapharma and UCB Pharma and consulting fees from Amgen, Radius Health, UCB Pharma, Renapharma, Parexel International and Consilient Health, all outside the presented work.

EV McCloskey has received consultancy/lecture fees/grant funding/honoraria from AgNovos, Amgen, AstraZeneca, Consilient Healthcare, Fresenius Kabi, Gilead, GSK, Hologic, Internis, Lilly, Merck, Novartis, ObsEva, Pfizer, Radius Health, Redx Oncology, Roche, Sanofi Aventis, UCB, ViiV, Warner Chilcott and I3 Innovus.

Alexandra Papaioannou has received funding from Amgen Research and honorarium.

M Schini received funding for her fellowship from the Medical Research Council Centre of Excellence for Musculoskeletal Ageing, from the Osteoporosis 2000 support group and from Roche Diagnostics and honoraria from MA Health care and Kyowa Kirin—all unrelated to this work.

S Silverman has received consultancy/grant support from Amgen and Radius.

JD Adachi, M Alokai, F Borgstrom, P Clark, C Cooper, MD Curiel, EM Curtis, EM Dennison, D Grigorie, H Johansson, E Liu, M Hilgismann, P Khashayar, R Lorenc, J-Y Reginster, R Rizzoli, EJ Shiroma, EM Simonsick, M Sosa-Henríquez P Szulc, L Vandendput and K Ward declare no competing interests in relation to this work.

## References

- Burnett-Bowie S-AM, Wright NC, Yu EW, Langsetmo L, Yearwood GMH, Crandall CJ, Leslie WD, Cauley JA (2024) The American Society for Bone and Mineral Research Task Force on clinical algorithms for fracture risk report. *J Bone Miner Res* 9:zjae048. <https://doi.org/10.1093/jbmr/zjae048>
- Vyas DA, Eisenstein LG, Jones DS (2020) Hidden in plain sight—reconsidering the use of race correction in clinical algorithms. *N Engl J Med* 383:874–882
- Flanagin A, Frey T, Christiansen SL, AMA Manual of Style Committee (2021) Updated guidance on the reporting of race and ethnicity in medical and science journals. *JAMA* 326:621–627
- Reid HW, Selvan B, Batch BC, Lee RH (2021) The break in FRAX: equity concerns in estimating fracture risk in racial and ethnic minorities. *J Am Geriatr Soc* 69:2692–2695 Erratum in: *J Am Geriatr Soc*. 2021 Oct 14
- Jain RK, Weiner M, Polley E, Iwamaye A, Huang E, Vokes T (2023) Electronic health records (EHRs) can identify patients at high risk of fracture but require substantial race adjustments to currently available fracture risk calculators. *J Gen Intern Med* 38:3451–3459
- Lewiecki EM, Wright NC, Singer AJ, Racial disparities (2020) FRAX, and the care of patients with osteoporosis. *Osteoporos Int* 31:2069–2071
- Kanis JA, Cooper C, Dawson-Hughes B, Harvey NC, Johansson H, Lorentzon M, McCloskey EV, Reginster J-Y, Rizzoli R (2020) FRAX and ethnicity. *Osteoporos Int* 31:2063–2067
- Barrett-Connor E, Siris ES, Wehren LE, Miller PD, Abbott TA, Berger ML, Santora AC, Sherwood LM (2005) Osteoporosis and fracture risk in women of different ethnic groups. *J Bone Miner Res* 20:185–194
- Dawson-Hughes B, Cosman F, McClung M (2024) The American Society for Bone and Mineral Research Task Force on clinical algorithms for fracture risk report. *J Bone Miner Res* in press
- Dhaliwal R, Pereira RI, Diaz-Thomas AM, Powe CE, Yanes Cardozo LL, Joseph JJ (2022) Eradicating racism: an endocrine society policy perspective. *J Clin Endocrinol Metab* 107:1205–1215
- Noel SE, Santos MP, Wright NC (2021) Racial and ethnic disparities in bone health and outcomes in the United States. *J Bone Miner Res* 36:1881–1905
- Kellie SE, Brody JA (1990) Sex-specific and race-specific hip fracture rates. *Am J Public Health* 80:326–328
- Cauley JA, Wu L, Wampler NS, Barnhart JM, Allison M, Chen Z, Jackson R, Robbins J (2007) Clinical risk factors for fractures in multi-ethnic women: the Women's Health Initiative. *J Bone Miner Res* 22:1816–1826
- Wright NC, Saag KG, Curtis JR, Smith WK, Kilgore ML, Morrisey MA, Yun H, Zhang J, Delzell ES (2012) Recent trends in hip fracture rates by race/ethnicity among older US adults. *J Bone Miner Res* 27:2325–2332
- Fink HA, Butler ME, Claussen AM, Collins ES, Krohn KM, Taylor BC, Tikabo SS, Vang D, Zerzan NL, Ensrud KE (2023) Performance of fracture risk assessment tools by race and ethnicity: a systematic review for the ASBMR Task Force on clinical algorithms for fracture risk. *J Bone Miner Res* 38:1731–1741
- Leslie WD (2012) Clinical review: Ethnic differences in bone mass—clinical implications. *J Clin Endocrinol Metab* 97:4329–4340
- Looker AC, Melton LJ 3rd, Borrud LG, Shepherd JA (2012) Changes in femur neck bone density in US adults between 1988–1994 and 2005–2008: demographic patterns and possible determinants. *Osteoporos Int* 23:771–780
- Cauley JA, Lui LY, Ensrud KE, Zmuda JM, Stone KL, Hochberg MC, Cummings SR (2005) Bone mineral density and the risk of incident nonspinal fractures in black and white women. *JAMA* 293:2102–2108
- Johnell O, Borgstrom F, Jonsson B, Kanis J (2007) Latitude, socioeconomic prosperity, mobile phones and hip fracture risk. *Osteoporos Int* 18:333–337
- Kanis JA, Odén A, McCloskey EV, Johansson H, Wahl D, Cyrus Cooper C, on behalf of the IOF Working Group on Epidemiology and Quality of Life (2012) A systematic review of hip fracture incidence and probability of fracture worldwide. *Osteoporos Int* 23:2239–2256
- Crandall CJ, Larson J, LaCroix A, Cauley JA, LeBoff MS, Li W, LeBlanc ES, Edwards BJ, Manson JE, Ensrud K (2019) Predicting fracture risk in younger postmenopausal women: comparison of the Garvan and FRAX risk calculators in the Women's Health Initiative study. *J Gen Intern Med* 34:235–242
- Crandall CJ, Larson J, Cauley JA, Schousboe JT, LaCroix AZ, Robbins JA, Watts NB, Ensrud KE (2019) Do additional clinical risk factors improve the performance of Fracture Risk Assessment Tool (FRAX) among postmenopausal women? Findings From the Women's Health Initiative observational study and clinical trials. *JBMR Plus* 3(12):e10239. <https://doi.org/10.1002/jbm4.10239>
- Kanis JA, Oden A, Johansson H, McCloskey E (2012) Pitfalls in the external validation of FRAX. *Osteoporos Int* 23:423–431

24. Visser M, Kritchevsky SB, Goodpaster BH, Newman AB, Nevitt M, Stamm E, Harris TB (2002) Leg muscle mass and composition in relation to lower extremity performance in men and women aged 70 to 79: the health, aging and body composition study. *J Am Geriatr Soc* 50:897–904
25. Kebaetse M, Nkhwa S, Mogodi M, Masunge J, Gureja YP, Ramabu M, Mmopelwa T, Sharif I, Orford A, Harvey NC, McCloskey EV, Cauley JA, Kanis JA, Johansson H (2021) A country-specific FRAX model for Botswana. *Arch Osteoporos* 16(1):90. <https://doi.org/10.1007/s11657-021-00965-y>
26. Johansson H, Odén A, Lorentzon M, McCloskey E, Kanis JA, Harvey NC, Karlsson MK, Mellström D (2015) Is the Swedish FRAX model appropriate for Swedish immigrants? *Osteoporos Int* 26:2617–2622
27. Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care (2003) Unequal treatment: confronting racial and ethnic disparities in health care. In: Smedley BD, Stith AY, Nelson AR (editors). Washington (DC): National Academies Press (US)
28. Wright NC, Chen L, Saag KG, Brown CJ, Shikany JM, Curtis JR (2020) Racial disparities exist in outcomes after major fragility fractures. *J Am Geriatr Soc* 68:1803–1810
29. Lo JC, Hui RL, Grimsrud CD, Chandra M, Neugebauer RS, Gonzalez JR, Budayr A, Lau G, Ettinger B (2016) The association of race/ethnicity and risk of atypical femur fracture among older women receiving oral bisphosphonate therapy. *Bone* 85:142–147
30. Lo JC, Huang SY, Lee GA, Khandelwal S, Provus J, Ettinger B, Gonzalez JR, Hui RL, Grimsrud CD (2012) Clinical correlates of atypical femoral fracture. *Bone* 51:181–184
31. Black DM, Geiger EJ, Eastell R, Vittinghoff E, Li BH, Ryan DS, Dell RM, Adams AL (2020) Atypical femur fracture risk versus fragility fracture prevention with bisphosphonates. *N Engl J Med* 383:743–753
32. Nguyen HH, Lakhani A, Shore-Lorenti C, Zebaze R, Vincent AJ, Milat F, Ebeling PR (2020) Asian ethnicity is associated with atypical femur fractures in an Australian population study. *Bone* 135:115319. <https://doi.org/10.1016/j.bone.2020.115319>
33. LeBoff MS, Greenspan SL, Insogna KL, Lewiecki EM, Saag KG, Singer AJ, Siris ES (2022) The clinician's guide to prevention and treatment of osteoporosis. *Osteoporos Int* 33:2049–2102
34. Kanis JA, Chandran M, Chionh SB, Ganeson G, Harvey NC, Koh WP, Kwok T, Lau TC, Liu E, Lorentzon M, McCloskey EV, Tan KB, Vandenput L, Johansson H (2020) Use of age-dependent FRAX-based intervention thresholds for Singapore. *Arch Osteoporos* 15(1):104. <https://doi.org/10.1007/s11657-020-00782-9>
35. Chandran M, McCloskey EV, Thu WPP, Logan S, Hao Y, Tay D, Ang WC, Aung TKK, Choo KS, Ali A, Yan SX, Huang XF, Liu XM, Yong EL, Lekamwasam S (2018) FRAX® based intervention thresholds for management of osteoporosis in Singaporean women. *Arch Osteoporos* 13(1):130. <https://doi.org/10.1007/s11657-018-0542-5>
36. Kanis JA, Cooper C, Rizzoli R, Reginster J-Y, Scientific Advisory Board of the European Society for Clinical and Economic Aspects of Osteoporosis (ESCEO) and the Committees of Scientific Advisors and National Societies of the International Osteoporosis Foundation (IOF) (2019) European guidance for the diagnosis and management of osteoporosis in postmenopausal women. *Osteoporos Int* 30:3–44
37. Clark P, Denova-Gutiérrez E, Zerbini C, Sanchez A, Messina O, Jaller JJ, Campusano C, Orces CH, Riera G, Johansson H, Kanis JA (2018) FRAX-based intervention and assessment thresholds in seven Latin American countries. *Osteoporos Int* 29:707–715
38. Lesnyak O, Zakroyeva A, Babalyan V, Cazac V, Gabdulina G, Ismailov S, Lobanachenko O, Rudenka E, Tsagareli M, Johansson H, Harvey NC, McCloskey E, Kanis JA (2021) FRAX-based intervention thresholds in eight Eurasian countries: Armenia, Belarus, Georgia, Kazakhstan, the Kyrgyz Republic, Moldova, the Russian Federation, and Uzbekistan. *Arch Osteoporos* 16(1):87. <https://doi.org/10.1007/s11657-021-00962-1>
39. Naseri A, Bakhshayeshkaram M, Salehi S, Heydari ST, Dabbaghmanesh MH, Dabbaghmanesh MM (2024) FRAX-derived intervention and assessment thresholds for osteoporosis in ten Middle Eastern Countries. *Arch Osteoporos* 19(1):41. <https://doi.org/10.1007/s11657-024-01397-0>
40. Kanis JA, Harvey NC, Cooper C, Johansson H, Oden A, McCloskey EV, The Advisory Board of the National Osteoporosis Guideline Group (2016) A systematic review of intervention thresholds based on FRAX. A report prepared for the National Osteoporosis Guideline Group and the International Osteoporosis Foundation. *Arch Osteoporos* 11:25. <https://doi.org/10.1007/s11657-016-0278-z>
41. Ratnasingam J, Niyaz M, Mariyappan S, Ong T, Chan SP, Hew FL, Yeap SS, Velaiutham S, Thambiah SC, Lekamwasam S (2024) Age-dependent FRAX-based assessment and intervention thresholds for therapeutic decision making in osteoporosis in the Malaysian population. *Arch Osteoporos* 19:18. <https://doi.org/10.1007/s11657-024-01371-w>
42. Johansson H, Kwang YC, Chandran M, Schini M, Liu E, Lorentzon M, Vandenput L, Harvey NC, McCloskey E, Kanis JA (2024) A surrogate FRAX model for Brunei. *Aging Clin Exp Res*, in press.
43. Johansson H, Dela SS, Cassim B, Paruk F, Brown SL, Conradie M, Harvey NC, Jordaan JD, Kalla AA, Liu E, Lorentzon M, Lukhele M, McCloskey EV, Mohamed O, Chutterpaul P, Vandenput L, Kanis JA (2021) FRAX-based fracture probabilities in South Africa. *Arch Osteoporos* 16:51. <https://doi.org/10.1007/s11657-021-00905-w>
44. Bonham VL, Sellers SL, Gallagher TH, Frank D, Odunlami AO, Price EG, Cooper LA (2009) Physicians' attitudes toward race, genetics, and clinical medicine. *Genet Med* 11:279–286
45. Xiao X, Wu Q (2021) The utility of genetic risk score to improve performance of FRAX for fracture prediction in US postmenopausal women. *Calcif Tissue Int* 108:746–756
46. Forgetta V, Keller-Baruch J, Forest M, Durand A, Bhatnagar S, Kemp J, Nethander M, Evans D, Morris JA, Kiel DP, Rivadeneira F, Johansson H, Harvey N, Mellström D, Karlsson M, Cooper C, Evans DM, Clark R, Kanis JA, Orwoll E, McCloskey EV, Ohlsson C, Pineau J, Leslie WD, Greenwood CMT, Richards JB (2020) Development of a polygenic risk score to improve screening for fracture risk: a genetic risk prediction study. *PLoS Med* 17:e1003152. <https://doi.org/10.1371/journal.pmed.1003152>
47. Lu T, Forgetta V, Keller-Baruch J, Nethander M, Bennett D, Forest M, Bhatnagar S, Walters RG, Lin K, Chen Z, Li L, Karlsson M, Mellström D, Orwoll E, McCloskey EV, Kanis JA, Leslie WD, Clarke RJ, Ohlsson C, Greenwood CMT, Richards JB (2021) Improved prediction of fracture risk leveraging a genome-wide polygenic risk score. *Genome Med* 13(1):16. <https://doi.org/10.1186/s13073-021-00838-6>
48. Nethander M, Pettersson-Kymmer U, Vandenput L, Lorentzon M, Karlsson M, Mellström D, Ohlsson C (2020) BMD-related genetic risk scores predict site-specific fractures as well as trabecular and cortical bone microstructure. *J Clin Endocrinol Metab* 105(4):e1344–e1357. <https://doi.org/10.1210/clinem/dgaa082>
49. Popham RE, Schmidt W (1981) Words and deeds: the validity of self-report data on alcohol consumption. *J Stud Alcohol* 42:355–368
50. Watson CG, Tilleskjor C, Hoedeclock-Schow EA, Pucel J, Jacobs L (1984) Do alcoholics give valid self-reports? *J Stud Alcohol* 45:344–348
51. Kanis JA, Johansson H, Johnell O, Oden A, De Laet C, Eisman JA, Pols H, Tenenhouse A (2005) Alcohol intake as a risk factor for fracture. *Osteoporos Int* 16:737–742









52. Schini M, Johansson H, Harvey NC, Lorentzon M, Kanis JA, McCloskey EV (2023) An overview of the use of the Fracture Risk Assessment Tool (FRAX) in osteoporosis. *J Endocrinol Invest* 47:501–511
53. Kanis JA on behalf of the World Health Organization Scientific Group (2007) Assessment of osteoporosis at the primary health-care level. In: Tech Rep. Sheffield, UK: World Health Organization Collaborating Centre for Metabolic Bone Diseases
54. Kanis JA, Oden A, Johnell O, Johansson H, De Laet C, Brown J, Burckhardt P, Cooper C, Christiansen C, Cummings S, Eisman JA, Fujiwara S, Glüer C, Goltzman D, Hans D, Krieg M-A, La Croix A, McCloskey E, Mellstrom D, Melton LJ, Pols H, Reeve J, Sanders K, Schott A-M, Silman A, Torgerson D, van Staa T, Watts NB, Yoshimura N (2007) The use of clinical risk factors enhances the performance of BMD in the prediction of hip and osteoporotic fractures in men and women. *Osteoporos Int* 18:1033–1046
55. Chlebowski RT, Anderson GL, Lane DS, Aragaki AK, Rohan T, Yasmeen S, Sarto G, Rosenberg CA, Hubbell FA, Women's Health Initiative Investigators (2007) Predicting risk of breast cancer in postmenopausal women by hormone receptor status. *J Natl Cancer Inst* 99(22):1695–705
56. Goldstein I, Gerber Y, Ish-Shalom S, Leshno M (2018) Fracture risk assessment with FRAX using real-world data in a population-based cohort from Israel. *Am J Epidemiol* 187:94–102
57. Hippisley-Cox J, Coupland C (2009) Predicting risk of osteoporotic fracture in men and women in England and Wales: prospective derivation and validation of QFractures Scores. *Br Med J* 339:b4229
58. Leslie WD, Lix LM, Johansson H, Odén A, McCloskey E, Kanis JA (2010) Independent clinical validation of a Canadian FRAX tool: fracture prediction and model calibration. *J Bone Miner Res* 25:2350–2358
59. Hoff M, Meyer HE, Skurtveit S, Langhammer A, Sjøgaard AJ, Syversen U, Dhainaut A, Skovlund E, Abrahamsen B, Schei B (2017) Validation of FRAX and the impact of self-reported falls among elderly in a general population: the HUNT study, Norway. *Osteoporos Int* 28:2935–2944
60. Liu IT, Liang FW, Li CC, Chang YF, Sun ZJ, Lu TH, Chang CS, Wu CH (2022) Validation of the Taiwan FRAX® calculator for the prediction of fracture risk. *Arch Osteoporos* 17(1):27. <https://doi.org/10.1007/s11657-022-01068-y>
61. Xu G, Yamamoto N, Hayashi K, Takeuchi A, Miwa S, Igarashi K, Taniguchi Y, Araki Y, Yonezawa H, Morinaga S, Tsuchiya H (2020) The accuracy of different FRAX tools in predicting fracture risk in Japan: a comparison study. *J Orthop Surg (Hong Kong)* 28:2309499020917276. <https://doi.org/10.1177/2309499020917276>
62. Mousa J, Peterson MN, Crowson CS, Achenbach SJ, Atkinson EJ, Amin S, Khosla S, Davis JM 3rd, Myasoedova E (2023) Validating the Fracture Risk Assessment Tool Score in a US population-based study of patients with rheumatoid arthritis. *J Rheumatol* 50:1279–1286
63. Dagan N, Cohen-Stavi C, Leventer-Roberts M, Balicer RD (2017) External validation and comparison of three prediction tools for risk of osteoporotic fractures using data from population based electronic health records: retrospective cohort study. *BMJ* 356:i6755. <https://doi.org/10.1136/bmj.i6755>
64. Kanis JA, Johansson H, McCloskey EV, Liu E, Åkesson KE, Anderson FA, Azagra R, Bager CL, Beaudart C, Bischoff-Ferrari HA, Biver E, Bruyère O, Cauley JA, Center JR, Chapurlat R, Christiansen C, Cooper C, Crandall CJ, Cummings SR, da Silva JAP, Dawson-Hughes B, Diez-Perez A, Dufour AB, Eisman JA, Elders PJM, Ferrari S, Fujita Y, Fujiwara S, Glüer CC, Goldstein I, Goltzman D, Gudnason V, Hall J, Hans D, Hoff M, Hollick RJ, Huisman M, Iki M, Ish-Shalom S, Jones G, Karlsson MK, Khosla S, Kiel DP, Koh WP, Koromani F, Kotowicz MA, Kröger H, Kwok T, Lamy O, Langhammer A, Larijani B, Lippuner K, Mellström D, Merlijn T, Nordström A, Nordström P, O'Neill TW, Obermayer-Pietsch B, Ohlsson C, Orwoll ES, Pasco JA, Rivadeneira F, Schott AM, Shiroma EJ, Siggeirsdóttir K, Simonsick EM, Sornay-Rendu E, Sund R, Swart KMA, Szulc P, Tamaki J, Torgerson DJ, van Schoor NM, van Staa TP, Vila J, Wareham NJ, Wright NC, Yoshimura N, Zillikens MC, Zwart M, Vandenput L, Harvey NC, Lorentzon M, Leslie WD (2023) Previous fracture and subsequent fracture risk: a meta-analysis to update FRAX. *Osteoporos Int* 34:2027–2045
65. Vandenput L, Johansson H, McCloskey EV, Liu E, Åkesson KE, Anderson FA, Azagra R, Bager CL, Beaudart C, Bischoff-Ferrari HA, Biver E, Bruyère O, Cauley JA, Center JR, Chapurlat R, Christiansen C, Cooper C, Crandall CJ, Cumming SRS, da Silva JAP, Dawson-Hughes B, Diez-Perez A, Dufour AB, Eisman JA, Elders PJM, Ferrari S, Fujita Y, Fujiwara S, Glüer C-C, Goldstein I, Goltzman D, Gudnason V, Hall J, Hans D, Hoff M, Hollick RJ, Huisman M, Iki M, Ish-Shalom S, Jones G, Karlsson MK, Khosla S, Kiel DP, Koh W-P, Koromani F, Kotowicz MA, Kröger H, Kwok T, Lamy O, Langhammer A, Larijani B, Lippuner K, Mellström D, Merlijn T, Nordström A, Nordström P, O'Neill TW, Obermayer-Pietsch B, Ohlsson C, Orwoll ES, Pasco JA, Rivadeneira F, Schei B, Schott A-M, Siggeirsdóttir K, Simonsick EM, Sornay-Rendu E, Sund R, Swart KMA, Szulc P, Tamaki J, Torgerson DJ, van Schoor NM, van Staa TP, Vila J, Wareham NJ, Wright NC, Yoshimura N, Zillikens MC, Zwart M, Harvey NC, Lorentzon M, Draft Leslie WD, Kanis JA (2022) A meta-analysis of previous falls and subsequent fracture risk. *Osteoporos Int* 35:469–494
66. Kanis JA, Hans D, Cooper C, Baim S, Bilezikian JP, Binkley N, Compston J, Dawson-Hughes B, El-Hajj Fuleihan G, Johansson H, Leslie WD, Lewiecki EM, Luckey MM, Oden A, Papapoulos SE, Poiana C, Wahl DA, McCloskey E, the Task Force of the FRAX Initiative (2011) Interpretation and use of FRAX in clinical practice. *Osteoporos Int* 22:395–411
67. Tipton K, Leas BF, Flores E, Jepson C, Aysola J, Cohen J, Harhay M, Schmidt H, Weissman G, Treadwell J, Mull NK, Siddique SM (2023) Impact of healthcare algorithms on racial and ethnic disparities in health and healthcare [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); Report No.: 24-EHC004
68. Mafi A, Naqvi H, L'Esperance V (2024) Taking racism out of clinical guidelines. *BMJ* 30(385):q942. <https://doi.org/10.1136/bmj.q942>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.

## Authors and Affiliations

John A. Kanis<sup>1,2</sup>  · Nicholas C. Harvey<sup>3,4</sup> · Mattias Lorentzon<sup>1,5</sup> · Enwu Liu<sup>1</sup> · Marian Schini<sup>6</sup> · Bo Abrahamsen<sup>7</sup> · Jonathan D. Adachi<sup>8</sup> · Majed Alokail<sup>9</sup> · Fredrik Borgstrom<sup>10</sup> · Olivier Bruyère<sup>11</sup> · John J. Carey<sup>12</sup>  · Patricia Clark<sup>13,14</sup> · Cyrus Cooper<sup>3,4,15</sup> · Elizabeth M. Curtis<sup>3</sup>  · Elaine M. Dennison<sup>3,16</sup> · Manuel Díaz-Curiel<sup>17</sup> · Hans P. Dimai<sup>18</sup> · Daniel Grigorie<sup>19,20</sup> · Mickael Hiligsmann<sup>21</sup> · Patricia Khashayar<sup>22</sup> · Willem Lems<sup>23</sup> · E. Michael Lewiecki<sup>24</sup> · Roman S. Lorenc<sup>25</sup> · Alexandra Papaioannou<sup>26</sup> · Jean-Yves Reginster<sup>27</sup>  · René Rizzoli<sup>28</sup> · Eric Shiroma<sup>29</sup> · Stuart L. Silverman<sup>30</sup> · Eleanor Simonsick<sup>31</sup> · Manuel Sosa-Henríquez<sup>32</sup> · Pawel Szulc<sup>33</sup> · Kate A. Ward<sup>3,34</sup>  · Noriko Yoshimura<sup>35</sup> · Helena Johansson<sup>1,5</sup> · Liesbeth Vandenput<sup>1</sup>  · Eugene V. McCloskey<sup>2,6,36</sup>  · on behalf of the Board of IOF, and the IOF Working Group on Epidemiology and Quality of Life

✉ John A. Kanis  
w.j.pontefract@shef.ac.uk

Nicholas C. Harvey  
nch@mrc.soton.ac.uk

Mattias Lorentzon  
mattias.lorentzon@medic.gu.se

Enwu Liu  
enwu.liu@acu.edu.au

Marian Schini  
m.schini@sheffield.ac.uk

Bo Abrahamsen  
b.abrahamsen@physician.dk

Jonathan D. Adachi  
jd.adachi@sympatico.ca

Majed Alokail  
malokail@KSU.EDU.SA

Fredrik Borgstrom  
fredrik.borgstrom@quantifyresearch.com

Olivier Bruyère  
olivier.bruyere@uliege.be

John J. Carey  
john.j.carey@universityofgalway.ie

Patricia Clark  
clark@unam.mx

Cyrus Cooper  
cc@mrc.soton.ac.uk

Elizabeth M. Curtis  
bc@mrc.soton.ac.uk

Elaine M. Dennison  
emd@mrc.soton.ac.uk

Manuel Díaz-Curiel  
MDCuriel@fjd.es

Hans P. Dimai  
hans.dimai@medunigraz.at

Daniel Grigorie  
grigorie\_d@yahoo.com

Mickael Hiligsmann  
m.hiligsmann@maastrichtuniversity.nl

Patricia Khashayar  
patricia.kh@gmail.com

Willem Lems  
wf.lems@amsterdamumc.nl

E. Michael Lewiecki  
mlewiecki@gmail.com

Roman S. Lorenc  
roman.s.lorenc@gmail.com

Alexandra Papaioannou  
papaioannou@hhsc.ca

Jean-Yves Reginster  
jyr.ch@bluewin.ch

René Rizzoli  
Rene.Rizzoli@unige.ch

Eric Shiroma  
eric.shiroma@nih.gov

Stuart L. Silverman  
stuarts@bhillsra.com

Eleanor Simonsick  
simonsickel@grc.nia.nih.gov

Manuel Sosa-Henríquez  
msosah@hotmail.com

Pawel Szulc  
pawel.szulc@inserm.fr

Kate A. Ward  
kw@mrc.soton.ac.uk

Noriko Yoshimura  
noripu@rc4.so-net.ne.jp

Helena Johansson  
helena@statiq.se

Liesbeth Vandenput  
liesbeth.vandenput@acu.edu.au

Eugene V. McCloskey  
e.v.mccloskey@sheffield.ac.uk

1 Mary McKillop Institute for Health Research, Catholic University, AustralianMelbourne, Australia

2 Centre for Metabolic Bone Diseases, University of Sheffield, Sheffield, UK

3 MRC Lifecourse Epidemiology Centre, University of Southampton, Southampton, UK

4 NIHR Southampton Biomedical Research Centre, University of Southampton and University Hospital Southampton NHS Foundation Trust, Southampton, UK

5 Sahlgrenska Osteoporosis Centre, Institute of Medicine and Clinical Nutrition, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

- 6 Division of Clinical Medicine, School of Medicine and Population Health, University of Sheffield, Sheffield, UK
- 7 Odense Patient Data Explorative Network, Institute of Clinical Research, University of Southern Denmark, Odense, Denmark
- 8 Department of Medicine, McMaster University, Hamilton, Canada
- 9 Biochemistry Department, College of Science, Riyadh, Kingdom of Saudi Arabia
- 10 Quantify Research, Stockholm, Sweden
- 11 Research Unit in Public Health, Epidemiology and Health Economics, University of Liège, Liège, Belgium
- 12 School of Medicine, University of Galway, Galway, Ireland
- 13 Clinical Epidemiology Research Unit, Hospital Infantil de Mexico "Federico Gomez", Mexico City, Mexico
- 14 Faculty of Medicine of National Autonomous University of Mexico (Universidad, Nacional Autónoma de México), Mexico City, Mexico
- 15 NIHR Oxford Biomedical Research Centre, University of Oxford, Oxford, UK
- 16 Victoria University of Wellington, Wellington, New Zealand
- 17 Metabolic Bone Diseases Unit, Department of Internal Medicine, Hospital Universitario Fundación Jiménez Díaz, Universidad Autónoma Madrid, Madrid, Spain
- 18 Department of Internal Medicine, Division of Endocrinology and Diabetology, Medical University of Graz, Graz, Styria, Austria
- 19 Carol Davila University of Medicine, Bucharest, Romania
- 20 Department of Endocrinology & Bone Metabolism, National Institute of Endocrinology, Bucharest, Romania
- 21 Department of Health Services Research, CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands
- 22 International Institute for Biosensing, University of Minnesota, Minneapolis, USA
- 23 Department of Rheumatology, Amsterdam UMC, Location VUmc, Amsterdam, The Netherlands
- 24 New Mexico Clinical Research & Osteoporosis Center, Albuquerque, NM, USA
- 25 Multidisciplinary Osteoporosis Forum, Warsaw, Poland, Poland
- 26 McMaster University, Hamilton, ON, Canada
- 27 Protein Research Chair, Biochemistry Dept, College of Science, King Saud University, Riyadh, Kingdom of Saudi Arabia
- 28 Division of Bone Diseases, Geneva University Hospitals and Faculty of Medicine, Geneva, Switzerland
- 29 Laboratory of Epidemiology and Population Sciences, National Institute On Aging, Baltimore, MD, USA
- 30 Department of Medicine, Division of Rheumatology, Cedars-Sinai Medical Center, Los Angeles, CA, USA
- 31 Translational Gerontology Branch, National Institute On Aging Intramural Research Program, Baltimore, MD, USA
- 32 University of Las Palmas de Gran Canaria, Grand Canaries, Spain
- 33 INSERM UMR 1033, University of Lyon, Hospital Edouard Herriot, Lyon, France
- 34 MRC Unit The Gambia, London School of Hygiene and Tropical Medicine, Banjul, The Gambia
- 35 Department of Preventive Medicine for Locomotive Organ Disorders, The University of Tokyo Hospital, Tokyo, Japan
- 36 Mellanby Centre for Musculoskeletal Research, MRC Versus Arthritis Centre for Integrated Research in Musculoskeletal Ageing, University of Sheffield, Sheffield, UK