*Javaid IFR Editorial tracked*

**EDITORIAL**

**Assessment and management of imminent fracture risk in the setting of the fracture liaison service**

**Muhammad K Javaid ∙ Nicholas C Harvey ∙ Eugene V McCloskey** **∙ John A Kanis ∙ Cyrus Cooper**

|  |  |  |
| --- | --- | --- |
| **Author** | **Affiliation** | **Contact** |
| Muhammad K Javaid\* | Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. | [kassim.javaid@ndorms.ox.ac.uk](mailto:kassim.javaid@ndorms.ox.ac.uk) |
| Nicholas C Harvey | MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, UK | [nch@mrc.soton.ac.uk](mailto:nch@mrc.soton.ac.uk) |
| NIHR Southampton Biomedical Research Centre, University of Southampton and University Hospital |
| Eugene V McCloskey | Centre for Metabolic Bone Diseases, University of Sheffield, Sheffield, UK | [e.v.mccloskey@sheffield.ac.uk](mailto:e.v.mccloskey@sheffield.ac.uk) |
| MRC Versus Arthritis Centre for Integrated research in Musculoskeletal Ageing, Mellanby Centre for Musculoskeletal Research, University of Sheffield, Sheffield, UK |
| John A Kanis | Mary McKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia | [w.j.pontefract@shef.ac.uk](mailto:w.j.pontefract@shef.ac.uk) |
| Centre for Metabolic Bone Diseases, University of Sheffield Medical School, Sheffield, UK |
| Cyrus Cooper | MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, UK | [cc@mrc.soton.ac.uk](mailto:cc@mrc.soton.ac.uk) |
| NIHR Musculoskeletal Biomedical Research Unit, University of Oxford, Oxford, UK |

**Competing Interests**

JAK, NCH and EVM are responsible for the creation and maintenance of FRAX but derive no financial benefit. EVM has received consultancy/lecture fees/grant funding/honoraria from AgNovos, Amgen, AstraZeneca, Consilient Healthcare, Fresenius Kabi, Gilead, GSK, Hologic, Internis, Lilly, Merck, Novartis, Pfizer, Radius Health, Redx Oncology, Roche, Sanofi Aventis, UCB, Viiv, Warner Chilcott, and I3 Innovus. CC reports personal fees from Alliance for Better Bone Health, Amgen, Eli Lilly, GSK, Medtronic, Merck, Novartis, Pfizer, Roche, Servier, Takeda and UCB. NCH has received consultancy/lecture fees/honoraria/grant funding from Alliance for Better Bone Health, Amgen, MSD, Eli Lilly, Radius Health, Servier, Shire, UCB, Consilient Healthcare and Internis Pharma. MKJ reports personal fees from UCB, Amgen, Kyowa Kirin. JAK reports no additional competing interests.

\*Correspondence: Dr M Kassim Javaid, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. [Kassim.javaid@ndorms.ox.ac.uk](mailto:Kassim.javaid@ndorms.ox.ac.uk)

To address the care gap for individuals with a recent fragility fracture [1], service models in post-fracture care, such as fracture liaison services (FLS), are becoming a higher priority for policy makers [2, 3]. The purpose of this editorial is to draw attention to the need for changes in FLS systems to accommodate fracture risk stratification, and the streamlining of treatment initiation to optimise anti-fracture efficacy of FLS services.

A fragility fracture is certainly a well-established major risk factor for further fractures[4, 5]. Furthermore, current evidence suggests a particularly marked increase in risk over the first two years after a sentinel fracture; although the excess risk subsequently wanes, it never reverts to the pre-fracture baseline[6]. The time-dependency is illustrated by age in Table 1A where, in an Icelandic cohort, the observed 2-year probability of fracture is consistently higher than the 10-year probability divided by 5[7]. Consequently, in the 10-year period following an index fracture event, around 50% of subsequent fractures were observed to occur within the first 2 years[6].

*Table 1 here*

This time effect, of particular importance in the FLS setting, has been coined “imminent” fracture risk[8], to convey the urgency for appropriate assessment and treatment. High imminent risk is almost always associated with very high long-term risk in those who survive for the long term, since the effect of a fracture on future risk never completely disappears, and many other risk factors are not similarly time dependent[7, 9]. Further refinement can be applied, given that imminent fracture risk also varies by the site of recent fracture, with much higher impact following fractures of the hip, spine or humerus compared with other sites such as the distal forearm (Table 1B) [7, 10]. Importantly, the impact of fracture recency has received much attention of late, with several published models to estimate short term risk[9]; the best developed however incorporates adjustment to the outputs from the FRAX® tool, using age, sex, site and recency dependent multipliers[11]. The effect of imminent risk on the absolute 10-year probability can be captured within the FLS setting and readily linked to national guidance predicated on the 10-year time horizon[12]. This is a critical development since more detailed stratification of fracture risk within FLSs informs clinical decision-making about the choice of appropriate treatments. However, the impact of fracture recency is not captured by current fracture risk assessment tools, including FRAX, underestimating fracture risk in the FLS setting.

Given that the current FRAX algorithm does not incorporate the effect of recency or site of prior fracture, the question arises as to whether it might constitute an essential part of risk assessment in the FLS setting. This is reflected by guidelines that recommend anti-osteoporosis treatment after specific major fragility fractures without further risk assessment[13, 14]. However, the value of risk assessment extends beyond the initial treatment decision, as exemplified by the treat to target approach and the more general value of such information for future monitoring of treatment and encouragement of patient adherence[15]. While the bone community awaits algorithms that incorporate IFR and other factors such as the rate of bone loss, fracture while on treatment, and falls, pragmatic solutions for identifying patients at very high imminent risk include combining a high 10 year FRAX score with a major fragility fracture of the hip, pelvis, femur, vertebra or rib in the last 2 years[16]. Indeed the first steps towards quantifying the associated risk adjustment have already been established, with the recent development of algorithms to modify the output FRAX probability to account for recency and site of prior fracture[6, 7, 11].

The effect of fracture site and recency on FRAX 10-year probability has thus been documented in a series of studies[6, 17, 18], clearly demonstrating the lower probabilities derived where a prior fracture is included without reference to site or recency (current FRAX tool), compared with modifying the output FRAX probabilities to account for the excess risk associated with a fracture in the previous 2 years. The magnitude of the multipliers is age-dependent, being of lower magnitude with increasing age as a result of the association between recency of prior fracture and mortality risk, which is incorporated as a competing hazard in the FRAX tool[11]. At present the adjustments are based on a single cohort in Iceland, in which the large size and detailed information on timing and site of fractures has facilitated the analysis. Work in additional populations will permit validation and further refinement of these models. Such considerations notwithstanding, comparison of observed 10-year probabilities in Iceland with calculated 10-year probabilities modified for site and recency are congruent, with the observed probabilities tending to be a little greater than the FRAX estimate with no risk factors, reflecting the admixture of clinical risk factors in the cohort. Thus, for example, using calculated FRAX probabilities for Iceland, a woman at 80 years old with a prior fracture at any time in the past has a 10 year probability of major osteoporotic fracture of 34% (no other risk factors and BMI 22kg/m2), adjusted to 42.8% when the prior fracture is at the humerus within the previous 2 years. In comparison, the observed 10 year incidence from the Iceland cohort (Table 1), for major osteoporotic fracture after a humerus fracture in the preceding 2 years is 43.4%. As a further example, in women at 60 years the observed probability of major osteoporotic fracture following a humerus fracture in the preceding 2 years in Iceland is 30.1%. The corresponding 10-year probability for a 60 year old women (with a prior fracture at any time or site) from the current Iceland FRAX model is 18%, rising to 27.7% when the probability is modified to account for the prior fracture being at the humerus in the preceding 2 years[11]. These comparisons are summarised by age and prior fracture site in Table 1.

Having recognised and accommodated the impact of imminent fracture risk, a critical deliverable for an FLS is to rapidly initiate anti-osteoporosis therapy for patients at sufficiently increased risk of sustaining a further fracture as outlined by organistaional and patient level performance indicators[3, 19]. Concerns about a lack of efficacy in the very early post-fracture period are not supported by pre-specified analyses of a randomised controlled trial of zoledronate following hip fracture[20], and a sub-analysis of the VERO Trial demonstrated efficacy of teriparatide compared with risedronate after recent clinical vertebral fracture and low bone density[21]. Local, regional and national guidelines support clinical decision making for the choice of anti-osteoporosis medication, informed by the magnitude of future fracture risk. Trials have demonstrated clinically important differences between anti-osteoporosis therapies in terms of speed of onset and scale of bone protection[22, 23], and this has influenced clinical guidelines to now prioritise anabolic therapies for those at highest risk[12, 14, 24, 25]. Time to the reduction of fracture risk is a composite of a medication’s pharmacology and onset of action[26, 27] and factors that affect the time from sentinel fracture to the initiation of therapy. The latter component is within the control of FLS, and from a system-related perspective, the goal is to minimise the number of steps which the high fracture risk patient has to negotiate before receiving anti-osteoporosis medication. DXA is a major predictor of fracture risk[28] and most RCTs included low bone density as an inclusion criteria. Hence, DXA is a standard component of fracture risk assessment in many settings. However at the patient level, there is variable rapid access to DXA availability between countries as well as within countries[29] . Delays to bone density assessment are due system (e.g. DXA availability) and patient (pain, mobility, accessibility) factors The system delays have been highlighted by the COVID pandemic[30]. A delay in DXA leads to a delay treatment recommendation. Fracture risk assessment tools, particularly FRAX, have marked a step-change in clinical assessment by recognising that BMD was not the only relevant fracture risk predictor. Indeed, many of the non-BMD risk factors in FRAX have a relationship with BMD such that a higher FRAX risk is associated with a low underlying BMD[31]. Age itself remains a significant predictor of imminent fracture risk; for example, the 2-year fracture risk in a 90-year-old individual with a sentinel fracture exceeds the 10-year risk in 50 and 60-year-old individuals[12]. Based on these observations, some have questioned the need for BMD measurements at older ages, an approach that is reflected within NICE guidance[32], and certainly enables the initiation of treatment before a BMD measurement in orthogeriatric patients with a major fracture. Potential benefits from DXA, when it does not delay treatment initiation, are the use of baseline DXA/VFA to provide an assessment for vertebral fracture detection, the presence of which can also influence treatment choice[33], and to monitor subsequent treatment adherence and response such as in the treat to target setting. Whilst a previous DXA scan has been shown to improve initial treatment adherence at least in younger individuals[34], the balance of benefits and costs of repeated DXA imaging and treatment adherence in the FLS setting, where patients have already experienced a clinical event, requires further research.

In summary, practitioners in the FLS setting need to be aware of the impact of recency of fracture on fracture risk and the need for timely interventions. Whereas current fracture risk assessment tools underestimate future fracture risk in the FLS setting, the accommodation of fracture recency within tools such as FRAX should lead to enhanced decision-making in the management of patients attending the FLS. The ability to stratify risk and enable treatment decisions without BMD measurement in some very high risk patients could become standard practice within FLS.

**Compliance with ethical standards**

**Competing Interests**

JAK, NCH and EVM are responsible for the creation and maintenance of FRAX but derive no financial benefit. EVM has received consultancy/lecture fees/grant funding/honoraria from AgNovos, Amgen, AstraZeneca, Consilient Healthcare, Fresenius Kabi, Gilead, GSK, Hologic, Internis, Lilly, Merck, Novartis, Pfizer, Radius Health, Redx Oncology, Roche, Sanofi Aventis, UCB, Viiv, Warner Chilcott, and I3 Innovus. CC reports personal fees from Alliance for Better Bone Health, Amgen, Eli Lilly, GSK, Medtronic, Merck, Novartis, Pfizer, Roche, Servier, Takeda and UCB. NCH has received consultancy/lecture fees/honoraria/grant funding from Alliance for Better Bone Health, Amgen, MSD, Eli Lilly, Radius Health, Servier, Shire, UCB, Consilient Healthcare and Internis Pharma. MKJ reports personal fees from UCB, Amgen, Kyowa Kirin. JAK reports no additional competing interests.

**Table 1.** Observed probability of major osteoporotic fracture in Iceland by age, and site and recency for prior fracture: **A:** Observed 2- and 10-year probabilities of a major osteoporotic fracture (%) in men and women from Iceland by age following a humeral fracture within the past 2 years. Also shown is the 10-year probability divided by 5, a value that is consistently lower than the 2-year fracture probability; and FRAX 10-year probability of major osteoporotic fracture from the current Iceland model (BMI 22kg/m2; prior fracture of any site or recency; no other risk factors), and then this FRAX probability adjusted for humeral fracture in the previous 2 years; **B:** Observed 2- and 10-year probabilities of a major osteoporotic fracture (%) in men and women age 70 years from Iceland following a sentinel fracture within the past 2 years. Also shown is the 10-year probability divided by 5, a value that is again consistently lower than the 2-year fracture probability; and FRAX 10-year probability of major osteoporotic fracture from the current Iceland model (age 70 years, BMI 22kg/m2; prior fracture of any site or recency; no other risk factors), and then adjusted for site of prior fracture in the previous 2 years. (Data from Kanis 2021 [7]). Note the decreasing effect of recency on FRAX probability with increasing age, due to the competing effect of mortality. Note also that adjusted FRAX probability calculated with prior fracture (recency and site) uses no other risk factors, whereas the observed probabilities in the cohort reflect a population of individuals with a wide range of risk factors, so observed probabilities are expected to be somewhat higher than predicted in this context.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** | **Men** | | | | | **Women** | | | | |
| **Age (years)** | **Observed 2-year probability** | **Observed 10-year probability** | **Observed 10-year probability/5** | **FRAX 10-year probability** | **FRAX 10-probability adjusted for recency** | **Observed 2-year probability** | **Observed 10-year probability** | **Observed 10-year probability/5** | **FRAX 10-year probability** | **FRAX 10-probability adjusted for recency** |
| 50 | 3.2 | 14.3 | 2.9 | 7.7 | 12.0 | 4.9 | 21.7 | 4.3 | 9.7 | 19.0 |
| 60 | 4.7 | 20.0 | 4.0 | 12 | 17.0 | 7.3 | 30.1 | 6.0 | 18 | 27.7 |
| 70 | 6.9 | 25.1 | 5.0 | 15 | 21.8 | 10.7 | 39.1 | 7.8 | 27 | 37.5 |
| 80 | 9.4 | 24.9 | 5.0 | 17 | 21.3 | 15.0 | 43.4 | 8.7 | 34 | 42.8 |
| 90 | 11.1 | 17.5 | 3.5 | 16 | 13.6 | 19.3 | 36.9 | 7.4 | 30 | 32.4 |
| **B** |  |  |  |  |  |  |  |  |  |  |
| **Site of recent fracture** | **Observed 2-year probability** | **Observed 10-year probability** | **Observed 10-year probability/5** | **FRAX 10-year probability** | **FRAX 10-probability adjusted for recency** | **Observed 2-year probability** | **Observed 10-year probability** | **Observed 10-year probability/5** | **FRAX 10-year probability** | **FRAX 10-probability adjusted for recency** |
| Vertebral | 8.1 | 25.5 | 5.1 | 15 | 22.2 | 13.9 | 41.9 | 8.4 | 27 | 40.5 |
| Hip | 7.9 | 25.1 | 5.0 | 15 | 21.9 | 10.2 | 34.3 | 6.9 | 27 | 33.2 |
| Humeral | 6.9 | 25.1 | 5.0 | 15 | 21.8 | 10.7 | 39.1 | 7.8 | 27 | 37.5 |
| Distal forearm | 5.2 | 22.9 | 4.6 | 15 | 20.0 | 6.9 | 30.5 | 6.1 | 27 | 29.4 |

1. Skjødt MK, Khalid S, Ernst M, et al. (2020) Secular trends in the initiation of therapy in secondary fracture prevention in Europe: a multi-national cohort study including data from Denmark, Catalonia, and the United Kingdom. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 31:1535-1544

2. Javaid MK, Kyer C, Mitchell PJ, et al. (2015) Effective secondary fracture prevention: implementation of a global benchmarking of clinical quality using the IOF Capture the Fracture(R) Best Practice Framework tool. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 26:2573-2578

3. Javaid MK, Sami A, Lems W, et al. (2020) A patient-level key performance indicator set to measure the effectiveness of fracture liaison services and guide quality improvement: a position paper of the IOF Capture the Fracture Working Group, National Osteoporosis Foundation and Fragility Fracture Network. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA

4. Klotzbuecher CM, Ross PD, Landsman PB, Abbott TA, 3rd, Berger M (2000) Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research 15:721-739

5. Kanis JA, Johnell O, De Laet C, et al. (2004) A meta-analysis of previous fracture and subsequent fracture risk. Bone 35:375-382

6. Kanis JA, Johansson H, Oden A, et al. (2018) Characteristics of recurrent fractures. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 29:1747-1757

7. Kanis JA, Johansson H, Harvey NC, et al. (2021) The use of 2-, 5-, and 10-year probabilities to characterize fracture risk after a recent sentinel fracture. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 32:47-54

8. Roux C, Briot K (2017) Imminent fracture risk. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 28:1765-1769

9. McCloskey EV, Borgstrom F, Cooper C, Harvey NC, Javaid MK, Lorentzon M, Kanis JA (2021) Short time horizons for fracture prediction tools: time for a rethink. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 32:1019-1025

10. Johansson H, Siggeirsdottir K, Harvey NC, Oden A, Gudnason V, McCloskey E, Sigurdsson G, Kanis JA (2017) Imminent risk of fracture after fracture. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 28:775-780

11. Kanis JA, Johansson H, Harvey NC, Gudnason V, Sigurdsson G, Siggeirsdottir K, Lorentzon M, Liu E, Vandenput L, McCloskey EV (2020) Adjusting conventional FRAX estimates of fracture probability according to the recency of sentinel fractures. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA

12. Kanis JA, Johansson H, Harvey NC, Lorentzon M, Liu E, Vandenput L, McCloskey EV (2021) An assessment of intervention thresholds for very high fracture risk applied to the NOGG guidelines : A report for the National Osteoporosis Guideline Group (NOGG). Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 32:1951-1960

13. Ferrari S, Lippuner K, Lamy O, Meier C (2020) 2020 recommendations for osteoporosis treatment according to fracture risk from the Swiss Association against Osteoporosis (SVGO). Swiss Med Wkly 150:w20352

14. Camacho PM, Petak SM, Binkley N, et al. (2020) AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS/AMERICAN COLLEGE OF ENDOCRINOLOGY CLINICAL PRACTICE GUIDELINES FOR THE DIAGNOSIS AND TREATMENT OF POSTMENOPAUSAL OSTEOPOROSIS-2020 UPDATE. Endocr Pract 26:1-46

15. Cummings SR, Cosman F, Lewiecki EM, et al. (2017) Goal-Directed Treatment for Osteoporosis: A Progress Report From the ASBMR-NOF Working Group on Goal-Directed Treatment for Osteoporosis. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research 32:3-10

16. Cooper C, Javaid MK, Elliot M, Stephens D, Tanna N (2020 ) UK consensus guideline on the management of patients at low, high, and very high risk of osteoporotic fracture. [www.guidelines.co.uk](file:///C:\Users\kjavaid\Documents\DXA\IOF\CtheFracture\paper\IFR%20editorial\www.guidelines.co.uk)

17. Balasubramanian A, Zhang J, Chen L, Wenkert D, Daigle SG, Grauer A, Curtis JR (2019) Risk of subsequent fracture after prior fracture among older women. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 30:79-92

18. Toth E, Banefelt J, Åkesson K, Spångeus A, Ortsäter G, Libanati C (2020) History of Previous Fracture and Imminent Fracture Risk in Swedish Women Aged 55 to 90 Years Presenting With a Fragility Fracture. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research 10.1002/jbmr.3953

19. Akesson K, Marsh D, Mitchell PJ, McLellan AR, Stenmark J, Pierroz DD, Kyer C, Cooper C (2013) Capture the Fracture: a Best Practice Framework and global campaign to break the fragility fracture cycle. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 24:2135-2152

20. Eriksen EF, Lyles KW, Colon-Emeric CS, et al. (2009) Antifracture efficacy and reduction of mortality in relation to timing of the first dose of zoledronic acid after hip fracture. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research 24:1308-1313

21. Geusens P, Marin F, Kendler DL, et al. (2018) Effects of Teriparatide Compared with Risedronate on the Risk of Fractures in Subgroups of Postmenopausal Women with Severe Osteoporosis: The VERO Trial. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research

22. Kendler DL, Marin F, Zerbini CAF, et al. (2018) Effects of teriparatide and risedronate on new fractures in post-menopausal women with severe osteoporosis (VERO): a multicentre, double-blind, double-dummy, randomised controlled trial. Lancet (London, England) 391:230-240

23. Saag KG, Petersen J, Brandi ML, Karaplis AC, Lorentzon M, Thomas T, Maddox J, Fan M, Meisner PD, Grauer A (2017) Romosozumab or Alendronate for Fracture Prevention in Women with Osteoporosis. The New England journal of medicine 377:1417-1427

24. Kanis JA, Harvey NC, McCloskey E, et al. (2020) Algorithm for the management of patients at low, high and very high risk of osteoporotic fractures. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 31:1-12

25. Scottish Intercolligaite Guidance Network (SIGN) (2021) Management of osteoporosis and the prevention of fragility fractures. Edinburgh. (SIGN publication no. 142). [January 2021]. Available from URL: http://www.sign.ac.uk.

26. Inderjeeth CA, Chan K, Kwan K, Lai M (2012) Time to onset of efficacy in fracture reduction with current anti-osteoporosis treatments. Journal of bone and mineral metabolism 30:493-503

27. Deardorff WJ, Cenzer I, Nguyen B, Lee SJ (2021) Time to Benefit of Bisphosphonate Therapy for the Prevention of Fractures Among Postmenopausal Women With Osteoporosis: A Meta-analysis of Randomized Clinical Trials. JAMA Intern Med

28. Cummings SR, Black DM, Nevitt MC, et al. (1990) Appendicular bone density and age predict hip fracture in women. The Study of Osteoporotic Fractures Research Group. JAMA 263:665-668

29. Clynes MA, Westbury LD, Dennison EM, Kanis JA, Javaid MK, Harvey NC, Fujita M, Cooper C, Leslie WD, Shuhart CR (2020) Bone densitometry worldwide: a global survey by the ISCD and IOF. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 31:1779-1786

30. Fuggle NR, Singer A, Gill C, et al. (2021) How has COVID-19 affected the treatment of osteoporosis? An IOF-NOF-ESCEO global survey. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 32:611-617

31. Johansson H, Oden A, Johnell O, Jonsson B, de Laet C, Oglesby A, McCloskey EV, Kayan K, Jalava T, Kanis JA (2004) Optimization of BMD measurements to identify high risk groups for treatment--a test analysis. Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research 19:906-913

32. National Institute for Health and Care Excellence (2017) Bisphosphonates for treating osteoporosis. https://www.nice.org.uk/guidance/ta464/resources/bisphosphonates-for-treating-osteoporosis-pdf-82604905556677. Updated: Jul 8, 2019.

33. Lems WF, Paccou J, Zhang J, Fuggle NR, Chandran M, Harvey NC, Cooper C, Javaid K, Ferrari S, Akesson KE (2021) Vertebral fracture: epidemiology, impact and use of DXA vertebral fracture assessment in fracture liaison services. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 32:399-411

34. Dugard MN, Jones TJ, Davie MW (2010) Uptake of treatment for osteoporosis and compliance after bone density measurement in the community. J Epidemiol Community Health 64:518-522