

TABLE 4. Risk factors used in FRAX

- Age (40-90 y)
- Sex
- Weight^a
- Height^a
- Previous fracture
- Parental history of hip fracture
- Current tobacco smoking
- Use of glucocorticoids
- Rheumatoid arthritis
- Alcohol intake of more than two units daily
- Secondary osteoporosis^b
- FN BMD if available

BMD, bone mineral density; FN, femoral neck; FRAX, Fracture Risk Assessment Tool.

^aBody mass index is automatically computed from height and weight.

^bOnly included in calculation when BMD is not available.

Kanis JA, et al.⁴⁷

- **Age.** For any BMD value, older women are at higher fracture risk than are younger postmenopausal women.⁴⁵
- **Parental history of hip fracture.** The strongest component of a family history to predict fracture risk is a parental history of hip fracture.⁵⁴
- **Smoking.** Fracture risk in postmenopausal women who smoke is increased about 30%, independent of BMD.⁵⁵
- **Excessive alcohol intake.** Consuming more than three servings of alcohol daily is associated with a 38% and 68% increase risk of major osteoporotic and hip fracture, respectively.⁵⁶

Risk factors not incorporated into FRAX include those not available in the databases on which FRAX was based (eg, falls) or were not known when FRAX was developed (diabetes):

- **Falls.** Most fractures, including many vertebral fractures, occur after a fall from a standing height or less.^{57,58} As a result, risk factors for falls, including a history of recent falls; weakness; impaired balance, coordination, vision, or hearing; obesity; and arthritis, are also risk factors for fracture.
- **Diseases and drugs.** Poor health is a risk factor for fracture; most diseases are associated with a general increase in fracture risk (Table 3).^{4,7} Diseases and drugs such as type 2 diabetes, obesity, and proton pump inhibitors are associated with increased fracture risk without causing bone loss. Disorders and drugs that affect muscle strength and balance such as frailty, stroke, and antidepressant medications increase risks of falls and fracture.

Other known risk factors for fracture include dementia, low physical activity, thoracic kyphosis, rates of bone loss, and both weight and height loss.^{52,59}

Other risk-assessment methods.

Bone density can be assessed by techniques other than DXA, including ultrasound and quantitative computed tomography (CT). T-score values obtained with these techniques are not substitutes for T-scores of the hip or spine obtained with DXA because they may overestimate or underestimate BMD and thus fracture risk.⁶⁰ For those few patients who cannot have DXA measurements at the hip or spine, assessing fracture risk with FRAX without BMD provides

more useful information than does BMD measured by alternate techniques.

Biomechanical CT analyzes quantitative CT scans of the LS and hip with an algorithm called *finite element analysis* that provides validated estimates of bone strength in individual patients.⁶¹ Biomechanical CT predicts fracture risk, although its advantage over DXA is small. Access to biomechanical CT is limited, and its role in routine clinical practice has not been defined.

Trabecular bone score is a special software available for DXA machines that analyzes the heterogeneity of density distribution on routine LS DXA images. Trabecular bone score measurements correlate with trabecular microarchitecture and predict fracture risk independently from bone density.⁶² Trabecular bone score has recently been incorporated into FRAX.⁶³ Using trabecular bone score is most helpful in women whose fracture risk is near the treatment threshold.

Assessing fall risk, with special emphasis on a history of a recent fall, is an important part of risk assessment in older women.⁵⁷ The Stopping Elderly Accidents Deaths and Injury initiative developed by the Centers for Disease Control and Prevention provides an algorithm for fall-risk screening (www.cdc.gov/steady/pdf/STEADI-Algorithm-508.pdf).

Limitations to fracture-risk assessment.

There are limitations to the use of any of the individual fracture-risk assessment tools and of the FRAX assessment tool. FRAX underestimates fracture risk in patients with falls or diabetes and in those with low spine but not FN BMD.⁶⁴ In addition, current FRAX scoring does not allow input for quantification of risk factors, including dose of glucocorticoid, amount of alcohol intake, duration and amount of cigarette smoking, or the number, type, or recency of prior fractures.⁴⁷ Despite these limitations, FRAX has been validated as an accurate predictor of fracture probability in large populations in the United States and Canada.^{65,66} However, its performance in identifying individual patients who will or will not fracture is less robust.⁶⁷ FRAX does not accurately predict BMD, but that is not what it was designed to do.⁶⁸ Until there are practical and inexpensive methods to measure bone strength accurately, estimating fracture risk with FRAX will remain one of the most useful tools.

Indications for bone density testing

Bone density should be measured in postmenopausal women with risk factors for low bone density where knowing the result will influence clinical management:

- Those with a history of fracture since menopause
- Those with known medical causes of bone loss or fracture
- Those aged 65 years and older
- Those aged 50 years and older with one or more of these additional risk factors:
 - Body weight less than 127 lb (57.7 kg) or BMI less than 21 kg/m²
 - History of hip fracture in a parent
 - Current smoker