BMJ Open

Comparison of fracture risk calculators in elderly fallers: a hospital-based cross-sectional study

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To cite: Todorov G, Brook S, Quah Qin Xian N, *et al*. Comparison of fracture risk calculators in elderly fallers: a hospital-based cross-sectional study. *BMJ Open* 2022;**12**:e060282. doi:10.1136/bmjopen-2021-060282

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-060282).

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Received 16 December 2021
Accepted 29 June 2022

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ABSTRACT

Objective Elderly patients presenting with falls are known to carry an extremely high risk of future fragility fractures. Current osteoporosis guidelines recommend using fracture risk calculators such as FRAX, QFracture or Garvan to guide management. However, they differ considerably in their inputs and may therefore provide contrasting risk estimations in certain individuals. In this study, we compare these risk calculators in a high-risk cohort of elderly patients admitted to hospital with falls.

Design Hospital-based cross-sectional study.

Setting Secondary care, London, UK.

Participants Data from 120 consecutive elderly patients who had falls presenting to a single hospital over 4 months were collected. 10-year major and hip fracture risks were calculated using FRAX, QFracture and Garvan. 1-year major and hip fracture risks from QFracture were assessed against prospective incidence of fracture.

Results Median 10-year major fracture risk was: FRAX 19.5%, QFracture 26.0%, Garvan 32.5%. Median 10-year hip fracture risk was: FRAX 9.6%, QFracture 21.1%, Garvan 6.5%. Correlation between FRAX and QFracture was r=0.672 for major, r=0.676 for hip fracture (both p<0.0001); FRAX and Garvan r=0.778 (p<0.0001) for major, r=0.128 (p=0.206) for hip fracture; QFracture and Garvan r=0.658 (p<0.0001) for major, r=0.318 (p<0.001) for hip fracture. QFracture 1-year predicted major and hip fracture rates were 1.8% and 1.2%, respectively, compared with actual rates of 2.1% and 0%, respectively.

Conclusions Although strong correlations between calculators were observed in the study cohort, there were differences of up to 13% between estimated risks. QFracture captured several elderly-specific inputs not considered by other calculators and so projected higher fracture risk than the other calculators. QFracture provided 1-year fracture risks that were comparable with the prospective observed fracture incidence in the cohort. This study has important clinical implications for the use of fracture risk calculators to guide treatment decisions, particularly in the high-risk cohort of elderly patients admitted to hospital following falls.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A key strength of this study is that it is the first study to compare fracture risk calculators in elderly fallers admitted to hospital, which is a recognised high-risk cohort in healthcare systems worldwide.
⇒ Another strength is the prospective exploration of 1-year fracture incidence in a live clinical setting.
⇒ Another strength is the confirmation of the importance of this topic to patients in the focus group.
⇒ The study is limited by the short duration of follow-up.

INTRODUCTION

Fragility fractures are a major cause of global morbidity and mortality.[1–3] Over 200 million people are affected by osteoporosis worldwide,[4] and it is estimated that by 2050, there will be up to 21.3 million hip fractures annually.[5] Over one in three adult women and one in five men will sustain one or more fragility fractures in their lifetime.[6] Such fractures cause pain, disability and ultimately increased mortality.[7] Alongside morbidity and mortality there exists a huge economic cost with European Union countries alone spending $37 billion annually treating osteoporosis-related fractures.[8] This highlights the global importance of fragility fractures to patients' well-being and the larger economy.

Elderly patients presenting to hospital emergency departments following a fall represent a patient group at particularly high risk of future fragility fractures. Hospital admissions therefore serve as a unique opportunity to identify, assess and manage these patients to reduce future fracture risk in the real world.[9 10] In addition to falls assessment and appropriate management,[11] this includes assessing risk factors for osteoporosis, evaluating the need for dual energy X-ray absorptiometry (DEXA) scans to calculate bone mineral density (BMD) and, depending on risk stratification, initiating bone protection therapy such as bisphosphonates.[12 13]

Osteoporosis is defined as DEXA BMD T-score ≥2.5 SD below the normal BMD mean for young adult women.[14] However, the use of T-score alone as a basis for an intervention threshold is problematic as most

fragility fractures occur in individuals with a BMD T-score within the osteopenic range due to the higher number of patients within this range.[15–17] Furthermore, BMD is only one of several factors contributing to the physical strength of bone; geometry, microstructure, quality and material properties are additionally important and not routinely accounted for in DEXA scans. Indeed, BMD explains only around 50%–60% of the strength under non-pathological conditions and is therefore not a comprehensive predictor of whether bone will fracture.[18]

To assess individual fracture risk and to aid decisions on whether to initiate bone protection therapy, clinical risk calculators that integrate risk factors for fragility fracture risk have been developed and are freely accessible online. These provide a prediction of the probability of future fragility fracture and thereby identify patients warranting bone protection therapy. Estimating individual fracture risk and assessing against preset intervention thresholds are the most evidence-based and widely accepted methods for bone health management worldwide.[19]

However, it is currently unknown how these calculators perform in elderly fallers. This is highly important as elderly fallers make up a large percentage of daily hospital presentations worldwide, thereby affording a prime opportunity to address their bone health in the real-world setting. The three commonly used risk calculators are FRAX, QFracture and Garvan.[20] The key features and differences between these three fracture risk calculators are outlined below and in figure 1.

FRAX calculator

The FRAX calculator, developed by the WHO Collaborating Centre for Metabolic Bone Diseases in Sheffield, computes the 10-year probability of hip fracture or major osteoporotic fracture, defined as a 'clinical spine, hip, forearm or humerus' fracture.[21] The algorithm is based on meta-analyses from 12 independent international fracture studies comprising 60 000 men and women with over 250 000 person-years' follow-up and included over 1100 hip fracture and 3300 osteoporotic fracture cases. The meta-analyses examined the impacts on fracture risk of smoking, body mass index (BMI), steroid use, family history of fracture and prior fracture. Crucially and relevant to the current study, a history of falls was unavailable for the algorithm. An external validation study was performed using individual-level data from 11 population-based cohorts.[22] FRAX is applicable to patients aged 40–90 years. FRAX does not account for dose-responsiveness of several risk factors, such as smoking and alcohol, but does include the option of including a BMD measurement in the risk calculation. Besides calculating the 10-year probability of major osteoporotic fracture and hip fracture, FRAX (UK) provides guidance on intervention thresholds for further management ('treat' versus 'lifestyle advice and reassure') based on UK National Osteoporosis Guidelines Group guidance.[19] The patient may be classified as having low (<11%), intermediate (11%–24%) or high (>25%) probability of major fracture.

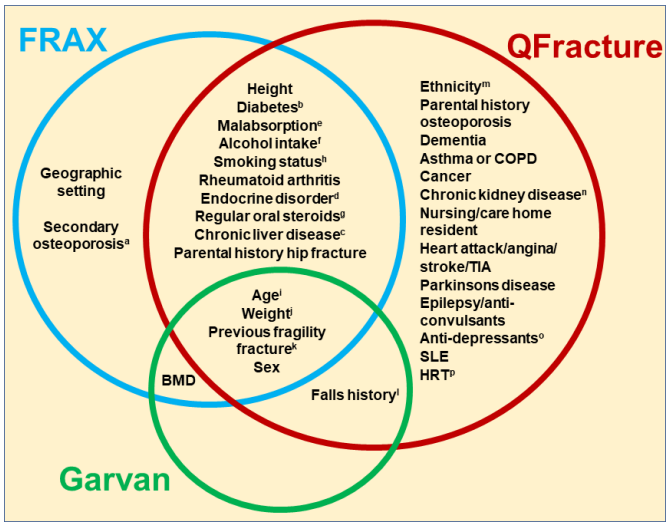

Figure 1 Common and lone input risk inputs for the FRAX, QFracture and Garvan risk calculators. [a]Includes type I diabetes mellitus, osteogenesis imperfecta in adults, untreated long-standing hyperthyroidism, hypogonadism, premature menopause (<45 years), chronic malnutrition, malabsorption and chronic liver disease. [b]FRAX groups type 1 diabetes mellitus as secondary osteoporosis; QFracture stratifies into type 1 and 2. [c]FRAX groups as secondary osteoporosis. [d]FRAX considers this to mean untreated long-standing hyperthyroidism or hypogonadism and considers these under secondary osteoporosis; QFracture only considers the following endocrine disorders and only in women: thyrotoxicosis, primary/secondary hyperparathyroidism, Cushing's syndrome. [e]FRAX considers as secondary osteoporosis; QFracture considers this to also encompass: inflammatory bowel disease, coeliac disease, steatorrhoea, blind loop syndrome. [f]FRAX only considers if ≥3 units alcohol/day; QFracture stratifies according to dose. [g]FRAX considers if currently on or exposed to oral glucocorticoids for >3 months of ≥5 mg prednisolone daily (or equivalent); QFracture considers this to mean ≥2 prescriptions in last 6 months. [h]FRAX only considers current smokers; QFracture has additional category for ex-smokers. [i]FRAX covers 40–90 years; QFracture 30–99 years; Garvan 50–96 years. [j]FRAX covers 25–125 kg; Garvan 10–150 kg; QFracture is not limited by a range. [k]Any number counted for all calculators; QFracture considers prior wrist, hip, spine or shoulder fractures; Garvan considers any site fractures occurring in those >50 years old, stratifying according to number (1, 2, ≥3). [l]Garvan considers falls in last 12 months, stratifying according to number (1, 2, ≥3); QFracture simply considers a 'history of falls'. [m]Input options include: white, Indian, Pakistani, Bangladeshi, other Asian, Chinese, black Caribbean, black African, other. [n]QFracture only considers stage 4 or 5 chronic kidney disease. [o]QFracture considers this to mean ≥2 prescriptions in last 6 months. [p]QFracture only considers oestrogen-only hormone replacement therapy (HRT). BMD, bone mineral density; COPD, chronic obstructive pulmonary disease; SLE, systemic lupus erythematosus; TIA, transient ischaemic attack.

QFracture calculator

The QFracture calculator is based on a prospective cohort study of data from over 350 UK General Practices, encompassing over 2 million patients aged 30–85 years. It

estimates the cumulative incidence of hip or major osteoporotic fracture over 1–10 years,[23] with major fracture defined as one occurring in the hip, wrist, shoulder or spine. QFracture can be used to assess individuals aged 30–99 years. For those aged >90 years, risk is calculated for the remaining years. For example, for a patient 95 years old, risk would be calculated over the next 5 years only. QFracture accounts for quantitative amounts of smoking and alcohol intake, reflecting their dose-dependent nature. Predictor variables (figure 1) include ethnicity, dementia and other comorbidities. Unlike FRAX, QFracture considers a history of falls, but not number of falls and no consideration is given for BMD. The predictive ability of QFracture has been externally validated in a UK population from general practitioner (GP) records.[23–25] There is no official threshold to define those at 'high risk' of fracture and who would benefit from therapeutic intervention. However, based on the QResearch General Practice database, the cut-off for the top 10% at risk is a 10-year major fracture risk of 11.1% in women and 2.6% in men.[24]

Garvan calculator

The Garvan calculator was developed by the Garvan Institute of Medical Research, Australia, using data acquired from the community-based Dubbo Osteoporosis Epidemiology Study.[26–29] This study followed 1208 women and 740 men aged over 60 years from 1989. It identified five main risk factors that markedly affected fracture outcome: age, BMD, body weight, fractures occurring after age 50 years and falls during the preceding year (figure 1).[26 27] The Garvan calculator assesses individuals aged 50–96 years to calculate 5-year and 10-year risks for hip and any fragility fracture. The latter contrasts with FRAX and QFracture which project the risk of major osteoporotic fractures in specific anatomical sites. Garvan has a limited number of inputs and leaves certain risk factors unaccounted for (figure 1). Number of fractures since age 50 years and number of falls over the last year (0, 1, 2 or ≥3) are included. Garvan classifies 5-year fragility fracture risks to be high (>10%), moderate (5%–10%) or low (<5%) but does not provide guidance regarding treatment thresholds.

Summary and aims

As these different risk calculators were developed from different data sources and vary in inputs, algorithm and output definitions, the resultant risk estimates are likely to differ. This has been described in other cohorts but not as yet in elderly fallers who are a group with high need for accurate fracture risk prediction.[30–32] Indeed, individuals over 70 years make up a large and important cohort, with an exceedingly high falls incidence of 42%.[33] The primary objective of this study was to investigate the novel question of how these risk calculators might diverge in their prediction of fracture risk in elderly fallers.

Identifying the strengths and weaknesses in comparison of the different risk calculators has potential to aid the goal of real-world osteoporosis fracture risk reduction in this high-risk population, especially by ensuring that those at highest risk are more likely to receive osteoporosis medications. Indeed, since assessment of fracture risk should be used to guide decisions regarding prescription of osteoporosis treatment, greater estimates of fracture risk may lead clinicians to be more likely to recommend pharmacological intervention, and vice versa, if fracture risk is assessed as lower.

We compared these three calculators in calculating 10-year fracture risk in a consecutive cohort of elderly fallers presenting to a single hospital as our primary objective. The 1-year fracture risk calculated by QFracture (not available from FRAX or Garvan) was also compared with actual prospective fracture data as an exploratory secondary objective.

METHODS

All patients aged ≥70 years who had an acute unplanned admission with a fall to the medical department of a large teaching hospital (Charing Cross Hospital, part of Imperial College Healthcare National Health Service Trust, London, UK) within the 4 months from 1 December 2018 to 31 March 2019 were included. The hospital has approximately 500 beds in total, and typically between 30 and 50 patients are admitted to the medical department in each 24-hour period. Falls were defined as per the understanding of the attending health professional who entered such terminology into the medical record.

Data were retrospectively collected in order to input all the required variables to obtain 10-year probabilities of major osteoporotic fracture and hip fracture using FRAX, QFracture and Garvan fracture risk calculators. Data were obtained from electronic hospital records and supplemented by contacting the patient or their GP in order to record patients' weight, height, history of fractures, onset of menopause and any other relevant history. DEXA BMD data were available for four patients.

If data remained unavailable or were outside limits for the different calculators, the following assumptions and adjustments were made: single imputation[34] was used to replace missing values for height and weight using age-specific and sex-specific mean data from the Health Survey for England 2019[35] as previously used in similar studies.[36] Thus, for patients attending on separate occasions, encounters were considered separately as these offered separate opportunities to assess risk; a history of falls was defined as at least one fall in the year prior to presentation; if weight was greater than the calculator limit, the maximum input values of 125 kg were entered for FRAX and 150 kg for Garvan; if age was greater than the calculator limit, the maximum value of 90 years was entered for FRAX; documented 'current smoker' status was equated to a 'moderate' smoker of daily 5–10 cigarettes and 'current alcohol consumer' was assumed to equal a daily intake of 3–6 units; if a 'silent' vertebral fracture was incidentally identified on routine imaging

without formal documented clinical fracture or if there was ≥20% vertebral height loss as per Genant staging of vertebral fractures,[37] then this was considered as a previous fracture; and, if parental osteoporosis or hip fracture was neither documented nor the patient was unable to recall, it was assumed that there was no history of either.

To prospectively compare the 1-year fracture risk calculated by QFracture with actual fracture incidence in the study population, at 1 year after their original presentation, patients' records were re-reviewed for documented evidence of new fractures or for fractures incidentally found on imaging.

Statistical analysis

Fracture risk data were not normally distributed by D'Agostino & Pearson testing. Therefore, Friedman test with Dunn's multiple comparison test was employed to compare the three risk calculator outputs. Correlations were performed using Spearman's rank correlation test, with $p<0.05$ considered statistically significant. Statistical analysis was performed using GraphPad Prism V.9 (GraphPad Software, La Jolla, California, USA).

Patient and public involvement

A focus group of 10 inpatients aged over 70 years (mean age 81 years), who had a history of at least one fall or a history of fragility fracture, were questioned on the following:

- Whether they thought osteoporosis was important.
- If subsequent fracture risk calculation after a fall is important.
- If deciding on management based on accurate risk is important.
- If they would take treatment if their risk was deemed high, any comments on research needed to clarify which risk calculator would be most appropriate for individuals.

All 10 patients thought that osteoporosis and choosing treatment based on accurate calculation of fracture risk were important. Nine said they would take treatment if their risk was deemed high and five thought that calculating fracture risk after a fall was important. The patient comments supported the performance of research that would clarify which risk calculator would be most appropriate for different clinical scenarios. In summary, the patient focus group clearly believed that this study was examining an important issue pertinent to their own health needs and that it would be beneficial to medical management of people similar to themselves.

RESULTS

Study population

During the 4-month study window, there were 120 consecutive presentations due to falls in individuals aged 70 years or over (49 male; 71 female), with mean age 83.3 years (range 70–95 years). Six patients were admitted twice.

Table 1 FRAX, QFracture and Garvan 10-year risks of major and hip fragility fracture

	Median risk, % (IQR)	
	Major fracture	Hip fracture
FRAX		
Overall	19.5 (11.8–26.0)	9.6 (5.6–16.3)
Male	10.0 (8.2–15.0)	6.1 (4.1–9.4)
Female	24.0 (20.1–32.0)	15.0 (9.5–21.0)
QFracture		
Overall	26.0 (16.9–38.4)	21.1 (11.7–32.3)
Male	19.0 (13.1–27.6)	15.6 (9.9–22.4)
Female	31.7 (22.4–42.4)	25.9 (15.5–36.6)
Garvan		
Overall	32.5 (20–45.3)	6.5 (3–16)
Male	18.0 (12.0–30.0)	14.0 (7.0–29.0)
Female	39.0 (30.0–56.0)	3.0 (2.0–8.5)

Sixty-eight of the 120 presentations (56%) had a history of falls in the prior year (online supplemental table 1).

Comparison of FRAX, QFracture and Garvan risk estimates

As shown in table 1 and figure 2, the median 10-year risk for major fracture was highest using Garvan (32.5%) followed by QFracture (26.0%) then FRAX (19.5%). The differences in the risks for 10-year major fracture were significant for FRAX versus QFracture, and FRAX versus Garvan (both $p<0.0001$), but not for QFracture versus Garvan ($p=0.0996$).

The median 10-year risk for fragility hip fracture was highest using QFracture (21.1%) followed by FRAX (9.6%) then Garvan (6.5%). Differences in the median

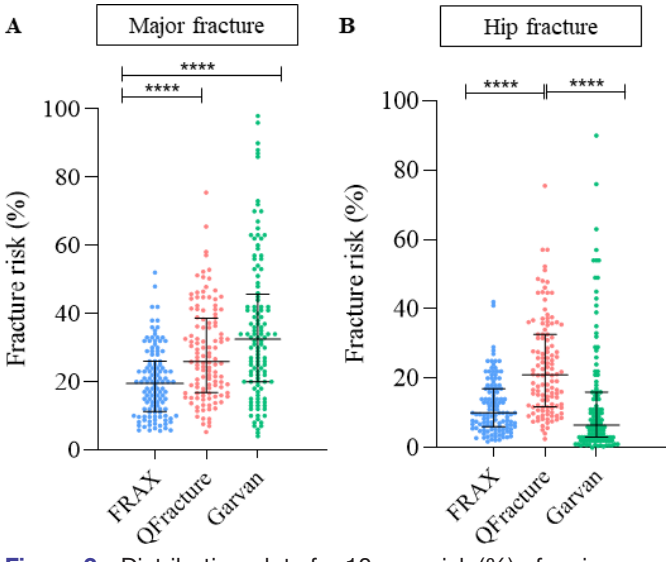

Figure 2 Distribution plots for 10-year risk (%) of major fracture (A) and hip fracture (B) between calculators. All individual raw data displayed with the median and IQR. ****P<0.0001 by Friedman test with Dunn's multiple comparison test, n=120 presentations.

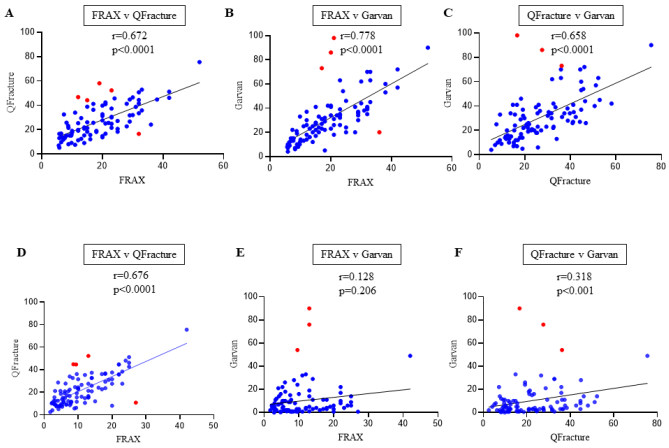

Figure 3 Comparison of the 10-year risk (%) of major fracture (A–C) and hip fracture (D–F) between calculators. FRAX versus QFracture (A and D), FRAX versus Garvan (B and E) and QFracture versus Garvan (C and F). Outliers lie ≥2 SD away from the correlation line (red dots). Spearman's rank correlation test.

risks for 10-year hip fracture were significant for FRAX versus QFracture, and QFracture versus Garvan (both p<0.0001), but not FRAX versus Garvan (p=0.747).

Correlations for 10-year risks

Due to the different upper age limits of each risk calculator (FRAX: 90 years; QFracture: 99 years; Garvan: 96 years), 21 presentations for patients >90 years were excluded for subsequent analyses, to permit fair comparison. Correlation coefficients were therefore calculated for 99 presentations (95 patients; 57 women, mean age 81.7 years; 42 men, mean age 80.5 years).

For major osteoporotic fracture, the strongest positive correlation was observed for FRAX-Garvan (r=0.778, p<0.0001), followed by FRAX-QFracture (r=0.672, p<0.0001), then Garvan-QFracture (r=0.658, p<0.0001) (figure 3A–C).

For hip fracture, the strongest positive correlation was observed for FRAX-QFracture (r=0.676, p<0.0001), followed by a weaker positive correlation for QFracture-Garvan (r=0.318, p<0.001). There was no significant correlation for FRAX-Garvan (r=0.128, p=0.206) (figure 3D–F).

Outliers

To further study the reasons for discrepancies between calculators, we investigated correlation outliers defined as cases ≥2 SD from the correlation line.

For differences in estimated 10-year risk of major fracture, when comparing FRAX with QFracture, there were five outliers (figure 3A). Patients with QFracture>FRAX risk had comorbidities considered by QFracture but not by FRAX such as dementia, previous falls and anti-depressant use (online supplemental table 2). Cases where Garvan>FRAX (figure 3B and online supplemental table 3) had a history of multiple fractures or falls (FRAX does not consider falls or the number of fractures). Comparing Garvan-QFracture, there were three outliers (figure 3C) which were the same as the Garvan>FRAX outliers (cases 9, 66 and 83 in online supplemental table 3), further indicating the strong weighting of falls and fracture history in Garvan.

For differences in estimated 10-year risk of hip fracture, there were four outliers when comparing FRAX and QFracture (figure 3D). The three cases of QFracture>FRAX risk were patients with multiple comorbidities contributing to a high QFracture risk (online supplemental table 4). For Garvan versus FRAX (figure 3E), there were three outliers with Garvan>FRAX risk which were the same three patients as in online supplemental table 2 (QFracture>FRAX) who had ≥2 falls in the preceding year (cases 106, 110 and 118).

Prospective 1-year fracture risk exploration

Median QFracture 1-year risk of a major fragility fracture in 95 patients aged between 70 and 90 years was 1.8% (IQR 1.15%–2.85%). The median 1-year risk of hip fracture was 1.2% (IQR 0.7%–2.15%). This translates to a predicted 1.7 of the total 95 patients expected to sustain a major fracture and 1.1 patients expected to sustain a hip fracture in the subsequent year.

At 1-year prospective follow-up, five of the 95 patients (5.3%) sustained a fracture, none of which were hip fractures. Three cases were accounted for by metacarpal, rib or pubic rami fractures, none of which met the QFracture anatomical description of major osteoporotic fracture (hip, wrist, shoulder or spine). Therefore, two cases (2.1%), both women, sustained a fracture under the QFracture definition compared with a predicted 1.7 cases (1.8%), demonstrating good predictive accuracy (online supplemental table 5). These two patients had QFracture predicted 1-year risks of major fracture (4.3% and 3.0%, respectively) that were above the median of the cohort, demonstrating their increased risk.

DISCUSSION

Previous studies have compared the performance of FRAX, QFracture and Garvan in different populations (online supplemental table 6), but here we present the first data in the specific cohort of elderly fallers who are admitted to hospital. This is important because this cohort consists of a high-risk population of patients and their presentation to hospital provides a prime opportunity for bone health assessment and intervention.

In our cohort, the Garvan risk calculator provided higher risk estimates than QFracture or FRAX for major fracture. This is in part due to the greater range of anatomical fracture sites considered by Garvan in its definition of major osteoporotic fracture, compared with QFracture and FRAX. For hip fractures, QFracture provided higher median risk estimates compared with FRAX and Garvan.

Overall, correlation between the risk calculators for major fracture was greatest between FRAX and Garvan (r=0.778, p<0.0001). Outliers reflected the varied inputs

between calculators and their different weighting, especially in the presence of history of falls and previous fracture. Correlation between the calculators for predicted risk of hip fracture was greatest between FRAX and QFracture.

Although ours is the first study to examine calculator discrepancies in elderly fallers, we identified previous studies examining the performance of fracture risk calculators in other patient cohorts (online supplemental table 6). Bolland et al.[30] reported similar findings in the elderly (however they were not specifically fallers like our cohort), with QFracture estimating higher major fracture risks than FRAX in major fracture rates. Additional studies report similar outcomes,[31] while other studies report higher major and hip fracture risks with FRAX than QFracture in other cohorts.[24 38 39] Further studies have compared the calculators in different sized populations prospectively and retrospectively.[32 40–55] For a given patient, the outputs can be quite different: for example, a 60 kg woman aged 80 years with height 160 cm and no risk factors exhibits a 10-year major fracture risk with FRAX of 18%, QFracture of 17.8% and Garvan 26%.

At prospective follow-up, we observed that QFracture performed well at estimating the projected incidence of major fragility fractures in our cohort (1.7% vs actual 2.1%). As QFracture considers falls and additional comorbidities frequently encountered in elderly fallers, this further lends credence to its use in this cohort of patients, though formal validation may require higher patient numbers to capture a higher number of events. Indeed, though the QFracture tool was derived from a large population cohort of 3 142 673 patients and has already been fully validated in a large study,[23 24] smaller scale testing in real-world clinical settings (such as this study) is valuable to monitor the reliability and relevance of the risk predictions. Though a 10-year follow-up may be helpful to assess longer term performance, it is important to consider that any data acquired from a 10-year follow-up are potentially misleading. The risk calculators predict the risk of fracture in absence of osteoporosis treatment, and so treatment which may be started based on initial assessment may confound the expected number of fractures on follow-up.

Strengths and limitations

There are some limitations to the current study. There may always be limitations to the comprehensiveness of some medical records and patients' recall of parental medical history may not always be accurate. Though with the limitation that there was no a priori sample size calculation, the study size was similar to that of other similar studies,[31 32 39 43 48] but there may be subtle differences between the risk calculators in certain patients that would become apparent with larger patient numbers. A much larger cohort would allow a more powerful analysis in the prospective validation part of the study. However, this was a secondary and exploratory element of the study, in order to observationally compare 1-year fracture incidence in a real-world clinical cohort with the predicted risk derived from a population cohort many times larger.[24] In this study, we did not directly assess if fracture risk calculations were indeed performed, and if so, if the choice of risk calculator influenced the osteoporosis management of the patients. Given the disparities in risk assessment identified, this warrants future study.

It is possible that vertebral fractures were underdiagnosed and under-reported, not least since they are frequently 'silent' and spine imaging was not performed opportunistically if not otherwise indicated in this cohort of patients. This highlights an issue requiring further work for future policy and global practice development.[56]

The strengths of the study include that it was performed in a single centre, bias was minimised by analysing all consecutive acute admissions of older adults with falls, use of electronic records with subsequent liaison with patients/GP ensured that missing data would be minimised, and the study size is comparable with other similar studies in the published literature. Furthermore, the patient focus group also confirmed the importance of the study topic.

This study identifies the clear need for flexibility in using appropriate risk calculators in different populations to improve healthcare delivery. As FRAX does not include falls as an input, it may be clinically more appropriate to use QFracture or Garvan in assessing these patients who have been admitted to hospital with falls. The National Institute for Health and Care Excellence[12] advocates the use of either FRAX or QFracture in assessing fracture risk, but FRAX is more commonly used in day-to-day practice. This study highlights the ongoing need to revisit and analyse the performance of clinical risk calculators and to determine which may more accurately serve different patient cohorts. In the field of osteoporosis, this is particularly important as we move from characterising the indication for osteoporosis therapeutics from purely reduced BMD to one based on overall fracture risk.[57] Indeed, decisions to start bone therapy lie with the treating clinician and should follow a holistic assessment of each patient.

CONCLUSION

We present the first data in the literature comparing fracture risk calculators in elderly fallers. Risk calculators are simple, efficient clinical tools which assess fragility fracture risk and help determine the need for osteoporosis medications such as bisphosphonates. Nevertheless, as we demonstrate, the outputs of different calculators can differ due to their varied inputs and algorithms. As risk thresholds are frequently used to guide bone therapy initiation, inconsistent recommendations may thus result depending on the choice of risk calculator to use. In elderly patients presenting with falls, this is particularly exaggerated as identified here.

Any emergency medical presentation with a fall offers a prime opportunity for clinicians to assess future fracture risk. Choosing which patients will benefit most from

osteoporosis treatment is important in order to reduce the future incidence of fracture, given the detrimental impact of fractures on patients' length and quality of life as well as on the health economy. Identifying those most likely to sustain a fracture and those most likely to benefit from osteoporosis treatment should continue to be a critical component of the medical care of elderly fallers.

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Contributors Study design—SB, GT and ANC. Study conduct—GT, SB, NQQX and SVW. Data collection—GT, SB and NQQX. Data analysis—SB. Data interpretation—GT, SB, NQQX and ANC. Drafting manuscript—GT and SB. Revising manuscript content—ANC, BF, SB, NQQX, SVW and GT. Approving final version of manuscript—GT, SB, NQQX, SVW, BF and ANC. SB takes responsibility for the integrity of the data analysis. ANC is responsible for the overall content as the guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not required.

Ethics approval This study was registered and approved by the Imperial College Healthcare NHS Trust (ref: ASM028).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. All patient-anonymised data are available on reasonable request.

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