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REVIEW

Fracture liaison services: improving outcomes for patients with osteoporosis

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Abstract: Fragility fractures are sentinels of osteoporosis, and as such all patients with low-trauma fractures should be considered for further investigation for osteoporosis and, if confirmed, started on osteoporosis medication. Fracture liaison services (FLSs) with varying models of care are in place to take responsibility for this investigative and treatment process. This review aims to describe outcomes for patients with osteoporotic fragility fractures as part of FLSs. The most intensive service that includes identification, assessment and treatment of patients appears to deliver the best outcomes. This FLS model is associated with reduction in re-fracture risk (hazard ratio [HR] 0.18–0.67 over 2–4 years), reduced mortality (HR 0.65 over 2 years), increased assessment of bone mineral density (relative risk [RR] 2–3), increased treatment initiation (RR 1.5–4.25) and adherence to treatment (65%–88% at 1 year) and is cost-effective. In response to this evidence, key organizations and stakeholders have published guidance and framework to ensure that best practice in FLSs is delivered.

Keywords: fracture liaison service, fractures, fall, osteoporosis, aged

Background

Osteoporosis is a chronic condition characterized by reduced bone mineral density (BMD) and microarchitectural deterioration, leading to increased bone fragility and fracture risk.[1,2] It is estimated to affect 1 in 3 women and 1 in 5 men over the age of 50 years.[3] Its prevalence increases with age, with an estimated prevalence in women of 6.3% among 50- to 54-year-olds, rising gradually to 47.2% among 80- to 84-year-olds.[4]

Osteoporosis is asymptomatic, and the first clinical manifestation of osteoporosis is often a low-trauma fragility fracture. Untreated osteoporosis will lead to an even higher risk of further fragility fractures that experts have termed a "fracture cascade"[5,6] or the "osteoporotic career".[7] For instance, sustaining a wrist fracture increases the risk of another fracture by 2-fold.[8] Studies have also shown that around half of women admitted with hip fractures, considered the most serious of all fragility fractures due to their high morbidity and mortality, have sustained a previous non-hip fragility fracture.[9–11] With an expanding aging population, we have seen a rise in the numbers of those affected by osteoporosis[4] and also an increasing prevalence of fractures, especially in those >75 years old.[12]

The conception of fracture liaison services

It has been widely reported that most patients with fragility fractures presenting to medical attention do not have the appropriate bone health assessment and treatment. It is reported that only 9%–50% of these patients proceed to have formal bone health

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assessment.[13–19] Simply treating the acute fracture is insufficient and must be followed by the appropriate osteoporosis treatment.[20] To ensure that the "osteoporosis treatment gap" is addressed, a robust proactive system needs to be in place to take responsibility for this, and the fracture liaison service (FLS) has been proposed as an effective model of care.

FLS operates by identifying patients presenting with fragility fractures; referring them onward for the necessary assessment of their bone health and fracture risk; and recommending or initiating the appropriate treatment, with the aim of preventing further fractures, especially more serious ones that are associated with higher morbidity.

One of the earlier published works on the FLS model was a program implemented in 1999 across 2 National Health Service Trusts working in collaboration in Glasgow, Scotland, and with it the term "Fracture Liaison Service" was coined.[21] Following this, similar services were set up in many countries, including Canada,[22–24] the Netherlands,[25,26] USA[27–31] and Australia.[32–34]

Models of FLS

Marsh et al[11] described 12 different models that have been described in scientific literature to deliver secondary fracture prevention. These ranged from programs aimed at increasing awareness of osteoporosis through to intensive programs that identify, investigate and initiate treatment. Some programs are completely delivered within the FLS model and some involve the general practitioner (GP) in primary care. Despite varying models, a common theme within these programs is that they are usually coordinated by a specified individual, usually a clinical nurse specialist, who will be case-finding, working to prescribed protocols, with assistance and referral access to specialist physicians.[11] The "4i" Lucky Bone FLS in Montreal, Canada, demonstrated that there was overwhelming consensus between their physicians and the decisions made by their specialist nurses when they were empowered within a system involving an order set to allow them to investigate and manage patients,[24] suggesting that such a service can be safely and efficiently run with minimal supervision from physicians.[35] In terms of identifying patients at risk of osteoporosis, most services would initiate an assessment in patients over the age of 50 years presenting with a fragility fracture,[21,25,26,28] although some centers also included women as young as 40.[22] Fragility fractures are those sustained following minimal trauma, eg, fall from a standing height, and those considered typical of osteoporotic fragility fractures.[36]

Ganda et al[37] conducted a similar review and grouped all published programs in scientific literature into 4 "types" of FLS models, referring to them as Types A to D.

- Type A is defined as a service that identifies, investigates and initiates treatment.
- Type B services identify and investigate patients but then refer back to the primary care physician for treatment initiation.
- Type C services identify patients at risk and inform them and their primary care physician. However, they do not undertake any assessment or treatment of the patients.
- Type D services identify at-risk patients and inform and educate them but take no further part in communicating their findings to other stakeholders in the patient's care.

This review aims to describe the outcomes demonstrated by an FLS model of care with reference to the types of service model as described by Ganda et al.[37]

FLS outcomes

Future fracture risk reduction

Reducing the risk of future fractures is the main aim of any FLS. The majority of studies that have looked at this were FLS models that proactively identified at-risk patients and initiated bone health assessments on them. Compared to either primary care follow-up or a comparable hospital without an FLS program, there was a significant reduction in subsequent fractures over 2–4 years following the index fracture in the FLS group (Table 1).[28,33,34,38–41]

At the Concord facility in Sydney, Australia, patients who were followed up in primary care by their GP had a markedly increased risk of subsequent fracture (hazard ratio [HR] 5.63, 95% confidence interval [95% CI] 2.73–11.6, $P<0.01$) after adjustments for other predictive factors, ie, age and weight, compared to those assessed by their Type A FLS over 2–4 years follow-up.[33] Another study based in Newcastle, Australia, reported that patients assessed by their Type A FLS had a lower rate of re-fracture, 5.1%, compared to those not assessed, 16.4% ($P<0.001$) after 2 years.[34] This same service was then compared with a comparable cohort from another hospital that does not have an FLS. It demonstrated that over 3 years there was a 30%–40% reduction in re-fracture rate among FLS patients (all fractures: HR 0.67, 95% CI 0.47–0.95, $P=0.025$; major fractures – hip, spine, femur, pelvis, humerus: HR 0.59, 95% CI 0.39–0.90, $P=0.013$).[40] Similarly, in the Netherlands, when a hospital with an FLS program was compared against one without, the FLS center had a reduced re-fracture rate, in a time-dependent fashion: after 1 year of follow-up, there was a non-significant 16% reduction (HR 0.84, 95% CI 0.64–1.10), but after 2 years of follow-up, there was a significant 56% reduction (HR 0.44, 95% CI 0.25–0.79).[41]

The Kaiser Permanente Southern California Healthy Bones Program, a Type A service, has shown itself to be

Table 1 Summary of evidence presented on fracture risk reduction in FLSs

Author (years)	Study design	Study participation	FLS type	Comparison	Outcome
Lih et al[33] (2011)	Prospective controlled intervention study	Age >45 years + minimal trauma fracture (non-vertebral)	A	Primary care follow-up	Reduced re-fracture rate in FLS: HR 5.63, 95% CI 2.73–11.6, $P<0.01$ for re-fracture in GP group
Van der Kallen et al[34] (2014)	Prospective – questionnaires	Age >50 years + minimal trauma fracture	A	Patients not attending follow-up clinic	Reduced re-fracture rate: 5.1% vs 16.4%, $P<0.001$
Dell et al[38] (2008)	Prospective cohort study using service data of 11 medical centres	Age >60 (all), or age >50 + fragility fracture/DXA scan/on osteoporosis treatment	A	Against previous performance	Reduced re-fracture rate: average 37.2% (range 23.1%–60.7%)
Greene and Dell[28] (2010)	Prospective cohort study using service data	Age >60 (all), or age >50 + fragility fracture/DXA scan/on osteoporosis treatment	A	Against previous performance	38.1% reduction in hip fractures compared to expected figures
Nakayama et al[40] (2016)	Historical cohort study	Age >50 years + minimal trauma fracture	A	Hospital without FLS	Reduced re-fracture rate: HR 0.67, 95% CI 0.47–0.95, $P=0.025$
Huntjens et al[41] (2014)	Retrospective cohort study	Age >50 years + non-vertebral fracture	A	Hospital without FLS	Reduced re-fracture rate, in time-dependent fashion. After 1 year: HR 0.84, 95% CI 0.64–1.10. After 2 years: HR 0.44, 95% CI 0.25–0.79
Astrand et al[42] (2012)	Retrospective – questionnaires	Age 50–75 years + wrist/ proximal humerus/vertebral/ hip fracture	B	Historic cohort (same hospital)	Reduced re-fracture rate: HR 0.58, 95% CI 0.40–0.87
Solomon et al[43] (2007)	Randomized controlled trial	Age >65 years, prior fracture or glucocorticoid usage	C/D	4 arms: C, D, modified C, usual care	No difference between the groups in terms of re-fracture

Notes: FLS type [37] A – Service which identifies, investigates and initates treatment; Type B – Service which identifies and investigates but refers patients back to their primary care physician to initiate treatment; Type C – Service which identifies patients at risk and informs their primary care physician to undertake the appropriate assessment and treatment; Type D – Service which identifies at risk patients and only inform and educate the at-risk patient.
Abbreviations: CI, confidence interval; DXA, dual energy X-ray absorptiometry; FLS, fracture liaison service; GP, general practitioner; HR, hazard ratio.

very successful and has been highly commended by the International Osteoporosis Foundation (IOF) Capture the Fracture initiative.[7] They have published their outcomes from their collection of 11 medical centers, with an average reduction in re-fracture rate of 37.2% (range 23.1%–60.7%) over the first 4 years.[38,39] Subsequent analysis revealed a 38.1% reduction in expected hip fractures.[28] A cohort study conducted in Sweden analyzing patients in the year before and after the implementation of a Type B FLS program demonstrated a reduction in re-fracture rate of 42% in the FLS group (HR 0.58, 95% CI 0.40–0.87) after 6 years.[42]

Less intense models focusing on improving patient and physician knowledge of bone health have not demonstrated any improvement on re-fracture rates. A randomized trial that allocated at-risk patients to 4 different arms, physician education, patient education, patient and physician education, and standard care, demonstrated no significant difference in re-fracture rates.[43]

Mortality

There are only a few studies describing mortality as an outcome associated with FLS programs. Over 2 years of follow-up, a Type A FLS demonstrated a 35% reduction in mortality following a fragility fracture compared with a comparable cohort not assessed by FLS (HR 0.65, 95% CI 0.53–0.79).[41] A large cohort study in the UK using hospital admission data from 11 hospitals also reported a reduction in 30-day mortality by 20% (HR 0.80, 95% CI 0.71–0.91) and 1-year mortality by 16% (HR 0.84, 95% CI 0.77–0.93) in patients admitted to hospital after a hip fracture.[44] This data set included hospitals with a newly implemented orthogeriatric service and an FLS program.

Bone health assessment

There is overwhelming evidence that FLS is associated with an increased number of patients referred for bone density assessment with dual energy X-ray absorptiometry (DXA). Compared to either usual care or a specified period pre-FLS, there was almost a 2- to 18-fold increase in DXA referrals. A more involved FLS program, such as a Type A model, was more likely to lead to higher referral rates compared to a less intensive model (Table 2).

A Scottish study compared 2 hospitals, 1 with a Type A FLS and 1 with usual care, and found that rates of offering DXA scans were significantly higher at the FLS center (85% vs 6% for humeral fractures, 20% vs 9.7% for hip fractures).[45]

Table 2 Summary of evidence presented on bone health assessment initiated by FLSs

Author (years)	Study design	Study participation	FLS type	Comparison	Outcome
Murray et al[45] (2005)	Retrospective comparison study – patient questionnaire	Age >50 years + proximal humerus/first intracapsular hip fracture	A	Different hospital with no FLS	Improved DXA scanning: humeral fractures: 85% vs 6%; hip fractures: 20% vs 9.7%
Majumdar et al[23] (2007)	Randomized controlled trial	Age >50 years + hip fracture	A	Same hospital, usual care (included education)	Improved BMD testing: 80% vs 29%, adjusted OR 11.6, 95% CI 5.8–23.5, $P<0.001$
Majumdar et al[46] (2008)	Randomized controlled trial	Age >50 years + wrist fracture	C (included GP reminders)	Same hospital, usual care (education)	Improved BMD testing: 52% vs 18%, RR 2.8, 95% CI 1.9–4.2, $P<0.001$
van Helden et al[25] (2007)	Retrospective comparison study	Females >50 years + new fracture	A – Nurse case-finds in ED	5 other hospitals, usual care	Improved DXA scanning: 71% vs 4%, RR 11, 95% CI 3.6–35.1
Ruggiero et al[47] (2015)	Prospective	Age >65 years + proximal femoral fracture	A	Historic cohort (same hospital)	Improved DXA scanning: 47.62% vs 14.53%, $P<0.0001$
Cosman et al[31] (2016)	Prospective – patient questionnaires	Age >50 years + rehabilitation following hip fracture	A	Historic cohort (same hospital)	Improved DXA scanning: 65% vs 35%
Dell et al[38] (2008) Greene and Dell[28] (2010)	Usage data since service implementation (11 medical centers)	All patients classed as high risk. Age >60 years; or age >50 years + previous fragility fracture/have had a previous DXA scan/on osteoporosis treatment	A	Against previous performance	DXA scanning: 247% over first 4 years, 263% over first 6 years
Axelsson et al[55] (2016)	Retrospective	Age >50 years + fracture of hip/vertebra/pelvis/shoulder/wrist	B	Historic cohort (same hospital)	Improved DXA scanning following FLS: 39.6% vs 7.6%
Hawker et al[48] (2003)	Matched cohort study. Followed up by telephone after 3 months	Age >40 years + fracture of wrist/hip/ankle/vertebra/humerus	C	Same clinics, usual care	DXA scanning more likely following contact with service: OR 5.22, $P<0.0001$
Solomon et al[43] (2007)	Randomized controlled trial	Age >65 years + prior fracture/glucocorticoid usage	C/D	4 arms: C, D, modified C, usual care	No difference between the groups in terms of numbers of DXA scans performed
Bliuc et al[49] (2006)	Randomized study	Minimal trauma fractures	D with the offer of free DXA	D without DXA offer	Improved DXA scanning when offered free alongside education: 38% vs 7%, $P=0.001$
Kuo et al[32] (2007)	Retrospective comparison study	Minimal trauma fractures	B	D	Improved DXA scanning following type B service: 83% vs 26%
Wallace et al[50] (2011)	Two-center retrospective comparison	Females >75 years + neck of femur fracture	B	Usual care	Improved documentation of osteoporosis risk factors with FLS: 83% vs 7%

Notes: FLS type [37] A – Service which identifies, investigates and initates treatment; Type B – Service which identifies and investigates but refers patients back to their primary care physician to initiate treatment; Type C – Service which identifies patients at risk and informs their primary care physician to undertake the appropriate assessment and treatment; Type D – Service which identifies at risk patients and only inform and educate the at-risk patient.
Abbreviations: BMD, bone mineral density; CI, confidence interval; DXA, dual energy X-ray absorptiometry; ED, emergency department; FLS, fracture liaison service; GP, general practitioner (primary care physician); OR, odds ratio; RR, relative risk.

Another study based in Edmonton, Canada, which randomly assigned patients with hip fracture to either an FLS or usual care, also reported a significant increase in BMD testing in the FLS group (80% vs 29%, adjusted odds ratio [OR] 11.6, 95% CI 5.8–23.5, $P<0.01$).[23] The same department subsequently evaluated this same model in patients with wrist fractures, and it also showed increased BMD testing in the FLS group (52% vs 18%, relative risk [RR] 2.8, 95% CI 1.9–4.2, $P<0.01$).[46] Even in studies where the comparison was made with a period pre-FLS, a significant increase in DXA referral was noted. An Italian study reported that their Type A inpatient FLS model of patients over 65 years with a proximal femoral fracture increased BMD testing by over 3-fold, from 14.5% to 47.6% ($P<0.01$).[47] A similar finding was reported in another study based in America where the initiation of an FLS during hip fracture rehabilitation increased BMD testing from 35% to 65%.[31] The Kaiser Permanente FLS have published multiple reports addressing the issue of osteoporosis investigation since their establishment in 2002. They report a 247% increase in total annual DXA scans over the first 4 years,[38] a 263% increase over the first 6 years,[28] and visual data showing further increase in annual DXA scans in their seventh and eighth years.[39] Findings from less intensive services have not been as robust. An education-based Type C service reported that patients followed up 3 months after their index fracture via a phone call were more likely to have been recommended a DXA scan (OR 5.22, $P<0.01$) compared to a control group that received no contact.[48] However, it was not reported how many of these recommendations translated into referrals. Another study employing an educational program (Types C and D) reported no significant difference in BMD assessment between the different groups, suggesting that the less intensive services may be less effective.[43] Hence, being able to initiate bone health assessment as part of an FLS program appears crucial in ensuring that a BMD assessment is done. This was demonstrated when a Type D service (education in the form of a letter) was compared with the same service with an additional offer for a free BMD assessment. The group offered the BMD assessment showed a significantly higher rate of investigation for osteoporosis (38% vs 7%, $P<0.01$).[49] The same department later compared an outpatient Type B service with the aforementioned Type D service, showing more BMD testing with the more involved Type B intervention (83% vs 26%).[32] Again, this reaffirms that a more intensive model is more efficient in initiating bone health assessment.

Referring a patient for BMD assessment with DXA is not a thorough assessment of fracture risk. Besides BMD measurement, a comprehensive bone health assessment includes assessment of other risks for future fractures. A 2-center comparison study (Type B vs standard service), comparing the practices in postmenopausal women with hip fractures, found much improved investigative work in terms of documentation of osteoporosis risk factors at the FLS center (83% vs 7%).[50] A Type A FLS from Sydney, Australia, reported that a total of 84% of patients identified by their service had a comprehensive assessment that also included a DXA scan.[51]

Overall, referrals for DXA from an FLS program range from 67.4% to 73.4% in Scotland[21] and 83.0% to 99.6% in the Netherlands.[26] Using an automated referral system has been reported to increase referral to 100%.[27] However, as many as 45% of those referred would either decline or not attend.[21,52]

Osteoporosis treatment initiation and adherence

Diagnosis of osteoporosis as part of the bone health assessment needs to be followed up with treatment as osteoporosis treatment has been demonstrated to reduce future fracture risk. Oral bisphosphonates are the most prescribed pharmacological agent. However, adherence with oral bisphosphonate has been reported to be low with only a third still persisting with them at 1 year.[53] Therefore, outcomes pertaining to osteoporosis treatment can be divided into the rate of initiation of therapy and the rate of adherence or persistence with treatment at later time points.

There is overwhelming evidence that FLS increases initiation of osteoporosis treatment (Table 3). The Type A services reported treatment initiation by an RR 1.50–4.25, with data gathered up to 2 years after contact with an FLS program.[23,29,34,45,47,54] The Edmonton series described treatment as an outcome measure in their trials. Their FLS compared to the standard service showed increased prescription of bisphosphonates in the FLS group at 6 months after hip fracture (51% vs 22%, adjusted OR 4.7, 95% CI 2.4–8.9, $P<0.01$) and wrist fracture (22% vs 7%, adjusted RR 2.6, 95% CI 1.3–5.1, $P=0.008$).[23,46] They also described more patients receiving "appropriate care", ie, their overall treatment was concordant with guidelines, in the FLS group.[23,46] The comparative study of the Fracture Prevention Clinic in Newcastle, Australia (Type A FLS vs standard service), also demonstrated increased treatment rates in the FLS group after an average of 2 years of follow-up (81.3% vs 54.1%, $P<0.01$).[34]

Table 3 Summary of evidence presented on treatment initiation by FLSs

Author (years)	Study design	Study participation	FLS type	Comparison	Outcome
Majumdar et al[23] (2007)	Randomized controlled trial	Age >50 years + hip fracture	A	Same hospital, usual care (included education)	Increased prescription of bisphosphonates: 51% vs 22%, adjusted OR 4.7, 95% CI 2.4–8.9, $P>0.01$
Majumdar et al[46] (2008)	Randomized controlled trial	Age >50 years + wrist fracture	C (included GP reminders)	Same hospital, usual care (education)	Increased prescription of bisphosphonates: 22% vs 7%, adjusted RR 2.6, 95% CI 1.3–5.1, $P=0.008$
Van der Kallen et al[34] (2014)	Prospective – questionnaires	Age >50 years + minimal trauma fracture	A	Patients not attending follow-up clinic	Increased treatment rate: 81.3% vs 54.1%, $P<0.01$
Murray et al[45] (2005)	Retrospective comparison study – patient questionnaires	Age >50 years + proximal humerus/first intracapsular hip fracture	A	Different hospital with no FLS	Increased treatment rate: 85% vs 20% – hip fractures, 50% vs 37% – humeral fractures
Ruggiero et al[47] (2015)	Prospective	Age >65 years + proximal femoral fracture	A	Historic cohort (same hospital)	Increased initiation of treatment: 48.51% vs 17.16% ($P<0.01$)
Axelsson et al[55] (2016)	Retrospective	Age >50 years + fracture of hip/vertebra/pelvis/shoulder/wrist	B	Historic cohort (same hospital)	Increased treatment rate: 31.8% vs 12.6%
Wallace et al[50] (2011)	Two-center retrospective comparison	Females >75 years + neck of femur fracture	B	Usual care	Increased treatment rate: 90.5% vs 60.9%, $P<0.01$
Solomon et al[43] (2007)	Randomized controlled trial	Age >65 years + prior fracture/glucocorticoid usage	C/D	4 arms: C, D, modified C, usual care	No difference between the groups in terms of treatment

Notes: FLS type [37] A – Service which identifies, investigates and initates treatment; Type B – Service which identifies and investigates but refers patients back to their primary care physician to initiate treatment; Type C – Service which identifies patients at risk and informs their primary care physician to undertake the appropriate assessment and treatment; Type D – Service which identifies at risk patients and only inform and educate the at-risk patient.
Abbreviations: CI, confidence interval; FLS, fracture liaison service; GP, general practitioner (primary care physician); OR, odds ratio; RR, relative risk.

In Scotland, the study by Murray et al[45] reported that rates of osteoporosis treatment after 6 months were significantly better at the FLS center (50% vs 27% for humeral fractures, 85% vs 20% for hip fractures). The inpatient FLS model described by Ruggiero et al[47] (>65 years old, proximal femoral fracture, comparison with historical cohort) also demonstrated an increase in the initiation of pharmacological treatment from 17.16% to 48.51% ($P<0.01$).

Even when treatment recommendation was made by the FLS but initiated in primary care by the GP, there was an increase in treatment rate after fracture from 12.6% to 31.8%, after 1 year of follow-up in 1 study.[55] Another study that looked at a cohort of older women with hip fractures showed that more patients recommended treatment by the FLS were prescribed treatment compared to standard care (90.5% vs 60.9%, $P<0.01$).[50] However, when no treatment recommendations were made (Type C or D model – educational programs), it made no difference to treatment initiation rates.[43] This was further highlighted in a study comparing a model that included treatment recommendation against an educational-based intervention only, where being able to recommend treatment led to higher rates of treatment initiation.[32]

When adherence with osteoporosis treatment was analyzed, usually bisphosphonates, there was wide variation in reported adherence and also when adherence was measured. Overall, adherence at 1 year has been reported to range from 44% to 80%.[47,54,56,57] In Pennsylvania, USA, the Geisinger Medical Center High-Risk patient Osteoporosis Clinic (HiROC), which includes patient follow-up at 3 months (via phone) and at 1 year, reported that adherence with oral bisphosphonates was 80.7% at 3 months and 67.7% at 12 months.[54] In another study, although adherence at 1 year improved since the start of a dedicated hip fracture FLS program compared to a pre-FLS period (44.07% vs 14.04%, $P<0.01$), it demonstrated a significantly low proportion of patients on treatment.[47] A Spanish study that includes patient education and telephone follow-up at 3, 6, 12 and 24 months recorded adherence rates to treatment of 72% at 1 year and 73% at 2 years, with significantly better adherence among women and those who had previously been treated with a similar drug.[56] Among patients initiated treatment in a French hospital, adherence was recorded as 80% after 1 year and 67.7% at final follow-up (mean 27.4 [11.7] months).[57]

Cost-effectiveness of an FLS

Besides clinical effectiveness, commissioning of an FLS needs to also weigh up the cost-effectiveness of such an intervention. A number of FLSs have conducted formal cost analysis of their existing FLSs, most of them using decision analysis models. Analyses conducted alongside a randomized trial of an FLS for hip fracture and wrist fracture patients with usual care reported that for every 100 patients managed, they would prevent 6 fractures (4 hips) and 3 fractures (1 hip), respectively. This would result in a saving of over US$250,000 to the health care system and up to 4 quality-adjusted life years (QALY) gained.[58,59] Analysis from another Canadian center, the Osteoporosis Exemplary Care Program in Toronto, showed that assessing 500 patients per year would prevent 3 hip fractures, saving CA$48,950 per year.[22] They also calculated that the employment of an FLS coordinator would still be a cost-effective measure even if they managed as few as 350 patients per year.[60] In the USA, a model based on a Type A FLS in Boston calculated that for every 10,000 patients managed, 153 fractures (109 hip) would be prevented, which equated to an overall saving of US$66,879, and there would be an increase in quality-adjusted life expectancy (QALE) of 37.4 years.[19] The Glasgow, UK, FLS developed a cost-effectiveness and budget-impact model, based on their internal data. They calculated that for 1,000 patients managed in their FLS program, which identifies, investigates and initiates treatment costing £290,000, they prevented 18 fractures (11 hips), leading to an overall saving of £21,000.[61]

In a separate study also based in Ontario, Canada, cost-effectiveness was compared between a less intense Type C model and a Type A model. For the Ontario Fracture Clinic Screening program (Type C FLS), 4.3 QALYs were gained and an extra CA$83,000 was spent per 1,000 patients, equating to a cost of CA$19,132 per QALY gained. Their subsequent enhanced FLS called the Bone Mineral Density Fast Track program (Type A FLS) was reported to be even more cost effective at CA$5,720 per QALY gained.[62] Hence, this almost 4-fold difference in cost-effectiveness suggests that a more intense model may deliver better outcomes.

These studies demonstrate that FLSs are cost-effective and cost-saving. Investment in FLS will reduce future fractures, which ultimately translates into lower overall health care cost. However, the cost-effectiveness of each FLS very much depends on the structure of each individual FLS in the context of the health care model of that respective geographical region.

Discussion

As demonstrated, a coordinated FLS is associated with improved outcomes in terms of reducing future fractures, morbidity and mortality, as a result of improved investigation and treatment of osteoporosis. The centers employing the more intensive services (Type A or B) whereby they take full responsibility for investigation and treatment achieve better results than less intensive services. The majority of the evidence available relates to Type A services, which identify, investigate and initiate treatment. We have made reference to some studies showing good results for Type B services (identify and investigate, but refer back to GP for treatment),[32,42,55] but there are no studies that directly compare Type A against Type B.

Certainly, the evidence is now strong enough for us to make a case that FLS needs no further justification, and focus should be on its widespread implementation. McLellan et al[61] calculated that it would cost in the region of £10 million in order to widely implement FLS across the UK and argue the case that this would be a worthwhile venture. The UK Department of Health developed and published a 5-year model of FLSs[63] based on the published standards[64] finding that these interventions could equate to a national saving of £8.5 million over 5 years. Many professional organizations have published reports or toolkits and set up campaigns in order to promote FLS implementation (Table 4).

A best practice framework

Although we have made the case for an FLS and that a more intense model works best, an operationalized framework is needed to ensure best practice is delivered. The IOF released a landmark document entitled Capture the Fracture in 2012[7] and went on to publish their Best Practice Framework (BPF) in 2013,[65] in order to provide guidance for institutions in the process of implementing an FLS and to allow evaluation of services using pre-determined outcome measures. It focused on 13 key domains – patient identification, patient evaluation, post-fracture assessment timing, identifying vertebral fragility fractures, adherence to local/regional/national guidelines, evaluating secondary cause of osteoporosis, access to falls prevention services, lifestyle risk assessment, initiation of treatment, review of treatment, communication between primary and secondary care, plan for long-term management (>12 months), and all fragility fractures being recorded on a database.[65]

Similarly, the UK National Osteoporosis Society (NOS) have also published their FLS clinical standards based on a 5IQ process of identifying those at risk, investigating

Table 4 Official publication from professional organizations and stakeholders on fragility fracture management and FLSs

Organization	Years	Report/campaign	Summary
The National Institute for Health and Care Excellence (NICE)	2012	Clinical Guideline 146: osteoporosis: assessing the risk of fragility fracture[75]	Describes recommended methods of assessment of risk of fragility fractures.
Department of Health	2009	Falls and fractures: effective interventions in health and social care[64]	Describes key targets in treatment and prevention of falls and fractures. "Objective 2" describes the role of FLSs in acute and primary care.
	2009	Fracture prevention services: an economic evaluation[63]	Reports findings of an economic model that equates to possible national savings of £8.5 million over 5 years, as a result of secondary fracture prevention.
British Orthopaedic Association (BOA)	2007	The Care of Patients with Fragility Fracture ("The Blue Book"), in collaboration with the British Geriatrics Society[76]	Outlines the problems associated with osteoporosis and fragility fractures, focusing on treatment of hip fractures and collaboration with inpatient geriatric care. Section 2.2 discusses the proposed role of FLS.
	2014	British Orthopaedic Association Standards for Trauma (BOAST) 9: Fracture Liaison Services[77]	Advocates implementation of FLS, suggests inclusion criteria and outlines 11 standards expected of FLSs.
International Osteoporosis Foundation (IOF)	2012	Capture the Fracture[7]	Defines the problem of osteoporosis and fragility fractures and reports early results from pioneering FLSs worldwide.
	2013	Best Practice Framework[65]	Provides standards and framework for regulation and objective assessment of FLSs.
	2014	International Fracture Liaison Service Toolkit[78]	Outlines the evidence justifying the need for FLS, how to implement and plan an FLS and guidance about wider implementation on a national level.
	2014	"Love Your Bones" Campaign[79]	Patient-orientated e-newsletter and campaign aimed at increasing awareness and uptake of available services.
National Osteoporosis Society (NOS)	2015	Effective Secondary Prevention of Fragility Fractures: Clinical Standards for Fracture Liaison Services[66]	Describes the need for FLS and the 5IQ model to achieve fracture prevention (identify, investigate, inform, intervene, integrate, quality).
	2015	Fracture Liaison Service Implementation Toolkit[80]	Online toolkit designed to help with setting up an FLS.
	2015	"Stop At One" Campaign[81]	Public-facing website aimed at improving awareness and increasing uptake of investigations and treatment.
Royal College of Physicians (RCP)	2013	Falls and Fragility Fracture Audit Programme (FFFAP)[82]	National clinical audit to assess the care received by patients with fragility fractures and inpatient falls, comprising National Hip Fracture Database, Fracture Liaison Service Database and National Audit of Inpatient Falls.
	2015	Fracture Liaison Service Database (FLS-DB)[67]	National audit to evaluate assessment and treatment of osteoporosis and falls. Composed of 2 components: facilities audit to determine what structures and policies are in place and a patient audit for existing FLSs to determine patient outcomes. The first report is expected in Spring 2017.
American Orthopaedic Association (AOA)	2009	Own the Bone[83]	Web-based publicly accessible program that allows entry of anonymized data into a registry and provides 10 specific prevention measures.
The American Society for Bone and Mineral Research (ASBMR)	2012	Making the First Fracture the Last Fracture: ASBMR Task Force Report on Secondary Fracture Prevention[84]	Publication in the *Journal of Bone and Mineral Research*, outlining the need for secondary prevention of fragility fractures and implementation of FLS.
National Bone Health Alliance (NHBA) (USA)	2013	Fracture Prevention Central (FPC)[85]	Online toolkit to help with setting up and running an FLS.
European Union Geriatric Medicine Society (EUGMS)	2016	A comprehensive fracture prevention strategy in older adults: EUGMS statement[86]	Position paper by the Interest Group on Falls and Fracture Prevention of the EUGMS, outlining existing evidence and advocating the need for a comprehensive and multidisciplinary fracture prevention strategy.

Abbreviation: FLS, fracture liaison service.

bone health and falls risk, informing patients about their condition and management plan, intervening with bone protection and falls intervention, integrating patient care between primary and secondary and maintaining quality of the service via database collection, audit and professional development.[66]

Within these 2 frameworks, specific benchmarking metrics are detailed in each domain. To aid this and ensure key improvements in quality are to be achieved, central data collection and monitoring, allowing comparison between services, are needed. In the UK, the introduction of the National Hip Fracture Database (NHFD) in 2007 has led to improved quality of care for hip fracture patients, such as reduced 30-day mortality and length of acute hospital stay. The act of collecting and publishing benchmarking metrics of individual hospitals allows health care providers to understand their own service, compare with other health care providers, track the progress of their service and inform changes, with the ultimate aim of improving the care delivered. Similar to what has been seen with the NHFD, such a database for FLSs could potentially lead to similar clinical benefits. Certainly, both the IOF and the NOS advocate a national database for this exact purpose. In the UK, a national audit program for FLSs was recently launched.[67]

Vertebral fragility fractures

A large number of FLS studies use a cohort of patients with hip fractures, as these are generally associated with the greatest morbidity and mortality, and appendicular fractures as these fractures present to medical attention allowing a good capture rate. However, another important group of osteoporotic fragility fractures are vertebral fractures. Most vertebral fractures are asymptomatic and only one-third present to medical attention.[68] Symptomatic and asymptomatic vertebral fractures are associated with significant frailty, morbidity and mortality.[69–72] In hospital, detection of vertebral fractures is poor and, even when detected, generally does not lead to initiation of any bone health assessment or treatment.[73] A key area for improvement in the way we deliver secondary prevention care in osteoporosis is the way that we detect and investigate patients following a vertebral fragility fracture, and this is reflected by the 4th domain of the BPF, and clearly further work is needed in this area. An FLS program specifically developed to identify vertebral fragility fractures admitted to hospital has already demonstrated a 3-fold increase in the referral rate for BMD assessment.[74]

Conclusion

FLSs have been shown to be beneficial for patients and health care providers, with the best outcomes demonstrated by a coordinator-led intensive services that take responsibility for the whole process, from patient identification following an incident fragility fracture through to investigation and treatment for osteoporosis and long-term follow-up to ensure adherence. Centers that do not currently have an FLS should take the necessary steps to implement one, as the potential benefits are only likely to increase over time with an aging population.

Disclosure

The authors report no conflicts of interest in this work.

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