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REVIEW

Post-fracture care programs for prevention of subsequent fragility fractures: a literature assessment of current trends

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Abstract

Post-fracture care (PFC) programs evaluate and manage patients with a minimal trauma or fragility fracture to prevent subsequent fractures. We conducted a literature review to understand current trends in PFC publications, evaluate key characteristics of PFC programs, and assess their clinical effectiveness, geographic variations, and cost-effectiveness. We performed a search for peer-reviewed articles published between January 2003 and December 2020 listed in PubMed or Google Scholar. We categorized identified articles into 4 non-mutually exclusive PFC subtopics based on keywords and abstract content: PFC Types, PFC Effectiveness/Success, PFC Geography, and PFC Economics. The literature search identified 784 eligible articles. Most articles fit into multiple PFC subtopics (PFC Types, 597; PFC Effectiveness/Success, 579; PFC Geography, 255; and PFC Economics, 98). The number of publications describing how PFC programs can improve osteoporosis treatment rates has markedly increased since 2003; however, publication gaps remain, including low numbers of publications from some countries with reported high rates of osteoporosis and/or hip fractures. Fracture liaison services and geriatric/orthogeriatric services were the most common models of PFC programs, and both were shown to be cost-effective. We identified a need to expand and refine PFC programs and to standardize patient identification and reporting on quality improvement measures. Although there is an increasing awareness of the importance of PFC programs, publication gaps remain in most countries. Improvements in established PFC programs and implementation of new PFC programs are still needed to enhance equitable patient care to prevent occurrence of subsequent fractures.

Keywords Care coordination · fracture liaison service · geriatric/orthogeriatric service · osteoporosis · post-fracture care

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Introduction

Osteoporosis is characterized by low bone density and structural deterioration of bone tissue that leads to fractures [1], even with low or minimal trauma experienced upon falling from a standing height or lesser impact. These fractures are commonly referred to as osteoporotic or fragility fractures [2, 3], and include hip, spine (clinical), wrist, humerus, tibia, and pelvic fractures. In 2000, an estimated 9 million fragility fractures occurred worldwide [4]. A more recent study that evaluated fractures at all sites and for all ages, using the framework of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019, reported an estimated 178 million fractures had occurred across 204 countries and territories in 2019, with most of the fractures occurring in the elderly [5]. Fragility fractures are associated with high rates of disability, loss of independence, reduced quality of life for patients and caregivers, and high costs to healthcare systems [3]. Despite the high associated morbidity and mortality, osteoporosis remains underdiagnosed and undertreated [6]. Individuals who experience one fragility fracture are at high risk of experiencing subsequent fractures. Post-fracture care (PFC) programs are systematic, coordinated care programs that identify, evaluate, and manage patients who have sustained a fragility fracture with the goal of preventing further fractures.

PFC programs exist in many forms including fracture liaison services (FLSs; also known as secondary fracture prevention [SFP]) programs [7], geriatric/orthogeriatric services (OGSs; also known as geriatric fracture centers [GFCs]) [8], and osteoporosis liaison services (OLSs) (Table 1). These programs vary in terms of personnel (lead or coordinator), fracture sites identified (hip vs. other fracture types), clinical setting (inpatient or outpatient), and scope of services offered (patient identification, investigation, or intervention) (Table 1). The two main models of PFC programs are outpatient FLSs and inpatient OGSs. The primary goal of FLSs is to prevent subsequent fragility fractures [7] and the primary goal of OGSs is to improve overall outcomes (morbidity, mortality, and/or physical function) for inpatients in the programs [8]. In general, FLSs and OGSs have some fundamental differences, such as outpatient and post-discharge care for FLSs vs. care for patients admitted to a hospital due to mostly hip fractures under OGSs (Table 1); however, these distinctions are not as clear cut in practice, with some programs incorporating elements of both models [9–12], though FLSs are more commonly applied to address outpatient care while in some situations, OGSs manage all inpatient care in addition to post-fracture care after patient discharge (Table 1). Also, in some countries, OGSs manage all hip fractures and FLSs manage secondary prevention for all other fragility fractures (Table 1).

Over the last few years, there has been a marked increase in the number of publications describing how PFC programs can improve identification, diagnosis, and treatment for patients with osteoporosis. In this article, we report results from a literature search and review we conducted to provide a cross-sectional snapshot of the global landscape of PFC programs. The key objectives were to understand trends in publications about PFC programs over the years; evaluate key characteristics of FLSs and OGSs; assess clinical effectiveness, geographic variations, and cost-effectiveness of PFC programs; and identify barriers and solutions to implementation of PFC programs.

Methods

Literature search parameters

We performed a search for peer-reviewed articles published between January 2003 and December 2020 that are listed in PubMed or Google Scholar using the literature search terms shown in Table 2. Publications eligible for assessment in this analysis included original research articles, reviews, guidelines/recommendations, case studies, editorials, and letters to the editor published between January 2003 and December

Table 1 Post-fracture care models for prevention of subsequent fragility fractures

Program model	Inpatient care	Orthogeriatric inpatient care[a]	Outpatient care	Post-discharge care	Coordinator based	Primary prevention
Fracture liaison service (FLS) or Fracture prevention service (FPS)	Yes/no	Yes	Yes	Yes	Yes	No
Orthogeriatric services (OGS) or Geriatric fracture center (GFC)	Yes/no	Yes	Usually no	Usually no	Yes/No	No
Osteoporosis liaison service (OLS)	Yes	Yes	Yes	Yes	Yes	Yes
Other post-fracture care (PFC)	Yes	Yes	Yes	Usually yes	Usually yes	No

[a]Focused on hip fracture care

Table 2 Search terms

General PFC	FLS and similar programs	Geriatric/orthogeriatric	Additional search parameters
Post-fracture care	Fracture liaison service	Geriatric fracture program	Published January 2003–December 2020
Post-fracture intervention	Fracture liaison	Geriatric fracture care	Listed in PubMed or Google Scholar
Secondary fracture prevention	Liaison service	Geriatric hip fracture care	Primary focus on PFC
Secondary fracture	Fracture prevention program	Geriatric fracture center	Abstract available
Fracture registry	Fracture service	Orthogeriatric	English language available
Interdisciplinary fracture prevention	FLS AND fracture	Orthogeriatric AND fracture prevention	Original research articles/reviews/commentaries
Osteoporosis re-fracture prevention	Fracture liaison program		
Fragility fracture	Integrated fracture care pathway		
Fracture coordinat(ion/or)	Fracture + coordinated care		

Review articles, editorials, and letters to the editor were included only if they contained new insights not included in original research articles

FLS, fracture liaison service; *PFC*, post-fracture care

2020; abstracts and congress proceedings were not eligible for assessment in this analysis. While most of the publications assessed were English language publications, a few articles written in other languages were included as long as an English language abstract was available. One author, in consultation with the other authors, assessed all retrieved articles for relevance to PFC programs. We included review articles, editorials, and letters to the editor in the assessment only if they contained new insights not covered in original research articles. Cases of ambiguity with regard to relevance to PFC programs were adjudicated through author discussions.

PFC program subtopics

We categorized the identified relevant articles into 1 of 4 preselected non-mutually exclusive PFC program subtopics based on assessment of keywords and abstract content. The selected subtopics were PFC Types, PFC Effectiveness/Success, PFC Geography, and PFC Economics (Table 3).

Outcomes

We reviewed articles that met the eligibility criteria for this analysis and evaluated trends in peer-reviewed articles on PFC programs between January 2003 and December 2020; identified and evaluated key characteristics of FLSs and OGSs; and assessed clinical effectiveness, geographic variations, and economics of PFC programs. We also highlighted barriers and solutions to implementation of PFC programs.

Results

Search results

Our search for peer-reviewed articles with relevance to PFC programs published between January 2003 and December 2020 and listed in PubMed or Google Scholar identified 784 unique articles that met the search criteria, with 746 of these articles listed in PubMed. The 784 articles included 638 original research articles, 81 reviews, 29 guidelines/recommendations, 22 case studies, 10 editorials, and 4 letters to the editor.

The number of publications per year increased from 2003 to 2020 (Fig. 1). Of the journals with ≥ 10 publications on PFC programs from January 2003 to December 2020, Osteoporosis International had the highest number with 152 articles (Online Resource Table 1). The most cited articles from January 2003 to December 2020 (Online Resource Table 2) reflect an interest in mostly hip fracture programs or OGSs; however, the most cited publications in the past 5 years (January 2015 to December 2020) reflect an interest in both FLSs and hip fracture/OGS programs (Online Resource Table 3).

Based on assessment of keywords and abstract content, most of the 784 articles were categorized into multiple PFC program subtopics (Fig. 2a, b), with 597 articles in PFC Types, 579 in PFC Effectiveness/Success, 255 in PFC Geography, and 98 in PFC Economics. Some articles

Table 3 PFC program subtopics

PFC program subtopic	Information in keywords or abstract content
PFC Types	1. PFC program types (FLS or OGS), new models of PFC programs, variations of established PFC models.
	2. PFC practices that may not fit the FLS or OGS models (e.g., automated patient identification and education programs).
	3. Direct comparisons between different models or specific PFC programs and standard of care.
	4. Remote or virtual PFC conducted through telephone, video conferencing, text messaging or other forms of virtual communication (telemedicine).
PFC Effectiveness/Success	1. Outcome metrics and proposals of standard or new metrics, including diversity of outcomes and effectiveness of programs and discussion of FLS classifications (A, B, C, D).
	2. Outcomes from FLS vs. OGS programs, including comparisons of programs at sites that have both inpatient and outpatient PFC programs.
	3. Baseline outcome data without PFC as well as population studies.
	4. Signals of service and patient outcome improvement due to execution of PFC such as increased screening, diagnosis, treatment, and reduced fracture rates including key performance indicators.
	5. Strong interest around the degree of harmonization between FLS and OGS programs.
	6. Treatment adherence/persistence.
	7. COVID-19 impact and opportunities for improved patient care.
PFC Geography (Trends in PFC Programs)	1. First-in-region PFC program.
	2. Regional and/or national surveys on PFC programs.
	3. Areas with different demographics, including adoption or expansion of PFC programs in underserved areas.
PFC Economics	1. Cost and cost-effectiveness of PFC programs, including costs to initiate and maintain PFC programs vs. benefit realized.
	2. Incentives and/or reimbursements related to PFC programs.
	3. Socioeconomic factors related to PFC programs.

FLS, fracture liaison service; *PFC*, post-fracture care; *OGS*, orthogeriatric service

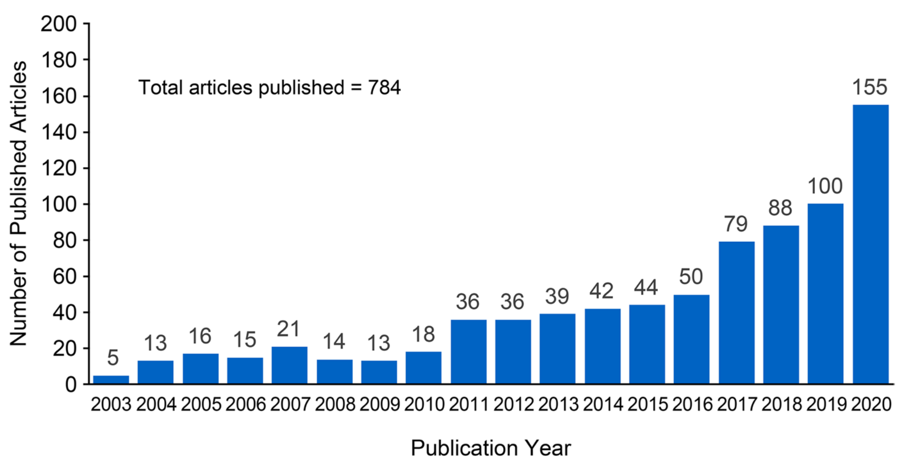

Fig. 1 Number of identified peer-reviewed articles with relevance to PFC programs published by publication year. Eligible articles were peer-reviewed original research articles, reviews, and commentaries of English language articles with relevance to PFC programs published between January 2003 and December 2020 and listed in PubMed or Google Scholar

fit into 1 subtopic only (Fig. 2b): 96 in PFC Types, 66 in PFC Effectiveness/Success, 20 in PFC Geography, and 7 in PFC Economics. However, 17 of the 784 articles did not fit into any of the pre-selected subtopics; most of these were descriptive studies.

Program types, scale, and target patient populations

Most articles were on FLSs and OGSs, which are the two primary models of PFC programs. FLSs have historically

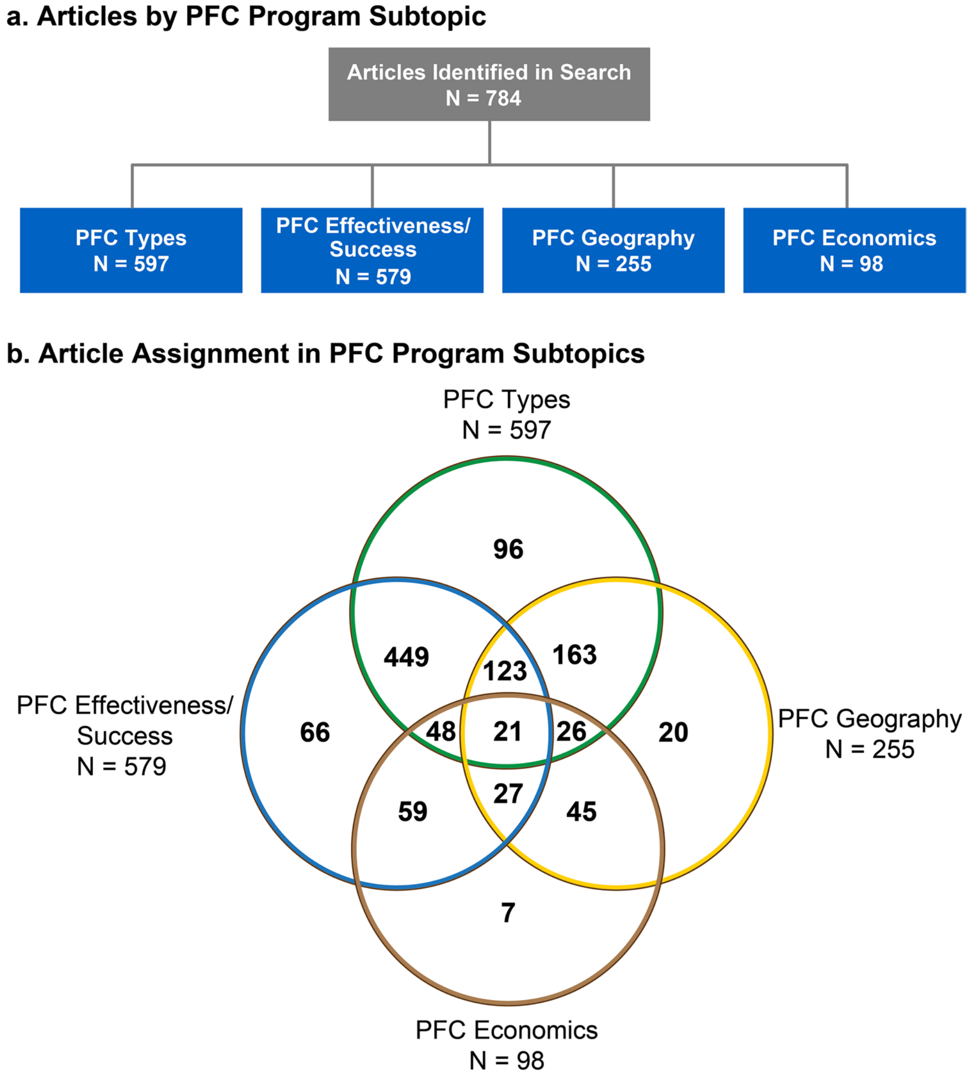

Fig. 2 Identified peer-reviewed articles with relevance to PFC programs published between January 2003 and December 2020 by selected PFC program subtopic (**a**) and fit into program subtopic (**b**). Articles were categorized into 1 of 4 pre-selected non-mutually exclusive PFC program subtopics as defined in Table 3 based on assessment of keywords and abstract content. Some articles fit into multiple subtopics; however, 17 of 784 articles did not fit into any of the subtopics (particularly articles on descriptive studies). *FLS*, fracture liaison service; *OGS*, orthogeriatric service; *PFC*, post-fracture care

been focused on all types of fragility fractures (including hip, spine [clinical], wrist, and humerus) with the primary goal of preventing subsequent fragility fractures (Fig. 3a). OGSs mainly focus on hip fractures with the primary goal of improving overall patient outcomes, including peri-operative morbidity, mortality, and physical function (Fig. 3b). FLSs and OGSs have notable functional differences and similarities [7, 8] (Fig. 3). Patient identification in FLSs is mainly through chart review and electronic medical record (EMR) notifications for any fragility fracture type, generally in patients ≥ 50 years of age. Patient identification in OGSs is through hospital admission, often limited to patients with hip fractures, although patients with other fracture types may also be included. Because OGSs enroll hospitalized patients, they also offer pre-surgical management of patients, including patient assessment, comorbidity management, and coordination of consultations and testing to reduce time to surgery. Both FLSs and OGSs offer fracture risk assessment; this is part of routine evaluation in FLSs and part of post-surgical management in OGSs. The methods of fracture risk assessment are similar and include bone mineral density (BMD) testing, spine imaging, review of parental history of fractures, use of fracture risk assessment tools/algorithms, blood tests, and biomarker profiling. Most FLSs have an intervention step that includes prescribing osteoporosis medication, diet, exercise, and fall prevention education. OGSs have a rehabilitation step that includes inpatient or outpatient physical therapy and fall prevention education. Patient follow-up methods are similar for FLSs and OGSs and include clinic

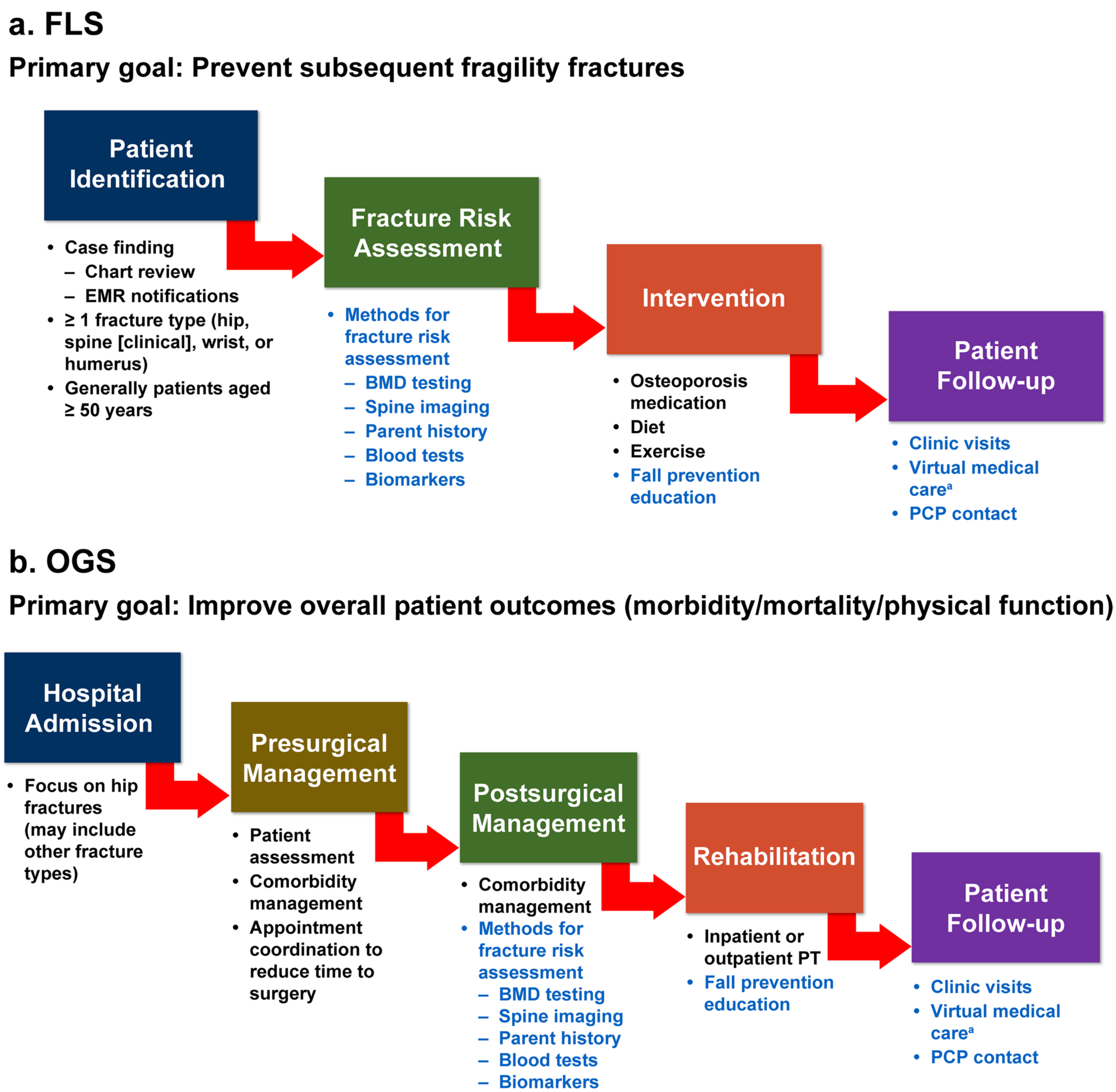

Fig. 3 Functions of PFC programs: FLS (**a**) and OGS (**b**). Blue font text denotes the common steps in both FLS and OGS programs. [a]Medical consultations through video calls, phone calls, emails, and text messaging. *BMD*, bone mineral density; *EMR*, electronic medical records, *PCP*, primary care physician; *PT*, physical therapy

visits, virtual care (medical consultations through video calls, phone calls, emails, and text messaging), and visits to primary care practitioners.

PFC programs that lack the basic elements of FLSs and OGSs but still support improvements in patient care were also identified. These include independent fracture registries [13, 14]; software applications supporting FLS/OGS workflows and automated patient identification [15, 16]; remote education/mentoring of healthcare professionals (HCPs) [17]; EMR prompts for screening/treatment [18, 19]; education/targeted advice for HCPs only [20, 21]; and prompts to HCPs and patients with no targeted education or specific recommendations [22–24]. This article focuses on FLSs and OGSs only.

Table 4 FLS types

Model	Functions Examples	Reference
Type A (3i)	Identification, assessment (risk factors, BMD, etc.), treatment initiation	
	FLS in Spain	Naranjo et al. Osteoporos Int 2015;26:2579-2585.
	C-STOP trial	Majumdar et al. J Bone Miner Res 2018; 33:2114-2121.
	FLS in a prospective cohort study	Senay et al. Arch Osteoporos 2019;14:87.
	FLS at a high-volume orthopedic hospital	Pennestri et al. Int J Environ Res Public Health 2019;16:4902.
	FLS in an orthopedic setting	Senay et al. J Bone Joint Surg Am 2020;102:486-494.
	FLS in patients over 70 years	Mugnier et al. Osteoporos Int 2020;31:765-774.
Type B (2i)	Identification, assessment, treatment recommendation only	
	FLS for capturing missed opportunities	Gupta et al. Osteoporos Int 2018;29:1861-1874.
	FLS in the Greek healthcare setting	Makras et al. Arch Osteoporos 2020;12.
	Hip fracture care in a hospital medicine service	Stephens et al. Hosp Pract 2021;49:41-46.
Type C (1i)	Education of patient and primary care physician	
	Catch a Break 1i FLS	Majumdar et al. 2017 Osteoporos Int 2017;28:1965-1977.
	Ontario Fracture Clinic Screening Program	Yong et al. Osteoporos Int 2016;27:231-240.
	NYU Osteoporosis Model of Care	Saxena et al. Geriatr Orthop Surg Rehabil 2015;6:276-281.
	Minimal FLS intervention	Roux et al. J Rheumatol 2013;40:703-711.
	FTOP FLS-like hip fracture program initiation in hospital	Dore et al. BMC Geriatr 2013;13:130.
	Centralized (Offsite) Osteoporosis Coordinator	Jaglal et al. Osteoporos Int 2012;23:87-95.
Type D (0i)	Education of patient only	
	Osteofit patient education-based intervention	van der Vet et al. Arch Osteoporos 2019;14:44.
	US Global Longitudinal Study of Osteoporosis in Women (GLOW)	Danila et al. J Bone Miner Res 2018;33:763-772.
	In-hospital education of hip fracture patients	Park et al. J Bone Metab 2018;25:107-113.
	PREVOST trial	Merle et al. Osteoporos Int 2017;28:1549-1558.
	Guardian Angel Project (Italy)	Alvaro et al. Clin Cases Miner Bone Metab 2015;12:43-46.
	Video/literature education	Bessette et al. Osteoporos Int 2011;22:2963-2972.

The FLS can be classified by the intensity (Types A–D) or number of interventions (0i–3i)

BMD, bone mineral density; *FLS*, fracture liaison service; *FTOP*, Fracture? Think Osteoporosis; *PFC*, post-fracture care

Publications on PFC programs by subtopic

PFC types

PFC-related publications continue to mention both FLSs and OGSs, with an increasing focus on treatment of elderly patients in recent years. We identified articles reporting on FLSs for the prevention of subsequent fragility fractures as well as diagnosis and management of vertebral fractures. We also identified articles on OGSs reporting peri-operative outcomes with limited reporting on osteoporosis management; however, there is a growing trend of PFC programs that combine elements of FLSs and OGSs [10–12, 25–38], resulting in increased rates of osteoporosis diagnosis and improved patient outcomes. We identified reports of FLS management of hip fractures [10, 32–35] and reports of orthogeriatric management of non-hip fractures [11, 31, 36]. With regard to diagnostic methods, additional screening and diagnostic tests for determining fracture risk and bone strength, including biomechanical computed tomography and determination of trabecular bone score, are being investigated for their utility in FLSs [39] and new scoring and risk identification systems are being incorporated to predict orthogeriatric outcomes [11, 30, 31].

FLSs can be classified by the intensity of care provided (Types A–D) or the number of interventions provided (0i–3i) [7, 40] (Table 4). Type A FLSs involve identification, intervention, and initiation of therapy; Type B involve identification and intervention; Type C involve identification with anticipation of primary care to intervene and initiate therapy; and Type D involve providing patient education only [40]. Type A and Type B FLSs typically involve a dedicated coordinator. A meta-analysis of data from reports published between 1996 and 2011 demonstrated that more intensive intervention types led to better outcomes in terms of investigation and treatment initiation [40, 41]. Most FLSs are Type A/Type B, and there is a general consensus that

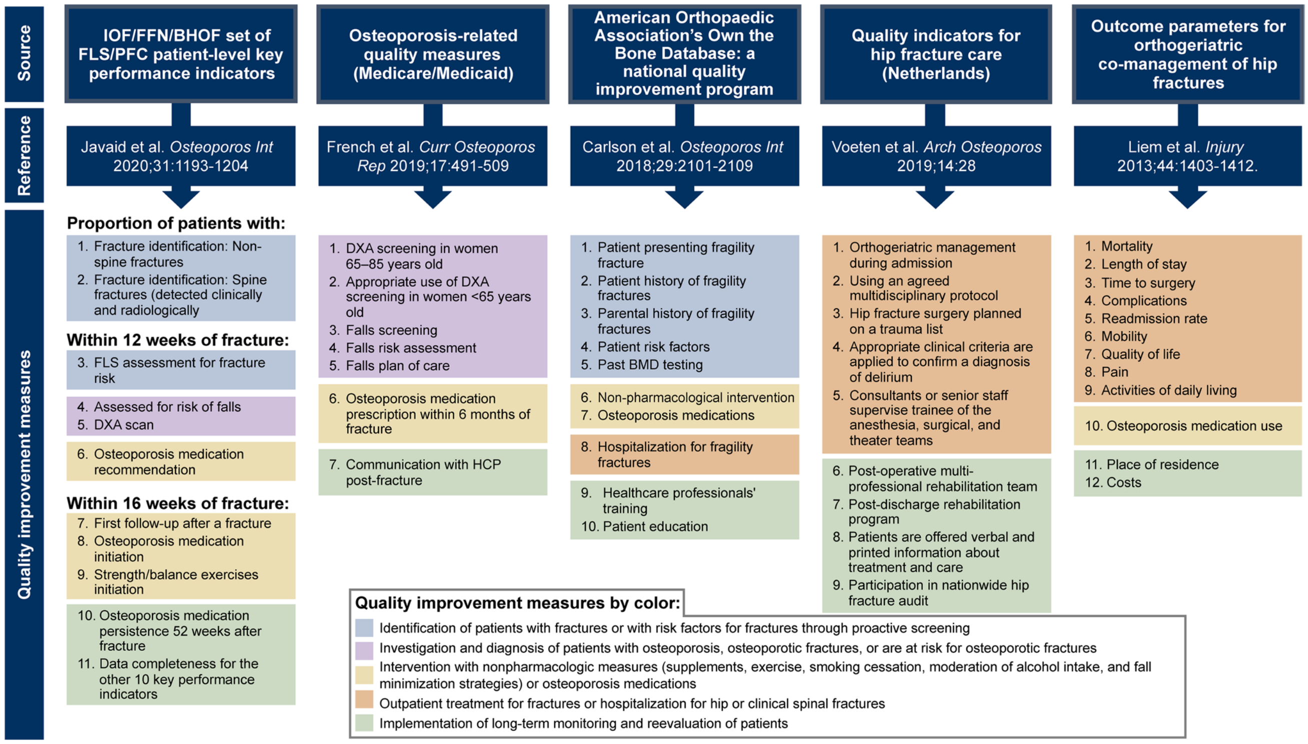

Fig. 4 Signals of harmonized quality improvement measures. *BMD*, bone mineral density; *DXA*, dual-energy X-ray absorptiometry; *FFN*, Fragile Fracture Network; *HCP*, healthcare professional; *FLS*, fracture liaison service; *IOF*, International Osteoporosis Foundation; *BHOF*, National Osteoporosis Foundation; *PFC*, post-fracture care

Type A FLSs are the most effective. Although Type A FLSs focus on treatment initiation, there were also Type A FLSs that reported on follow-up of patients and adherence to medications [42, 43] (Table 4). Very few Type C and Type D FLSs were identified (Table 4). Additionally, some virtual PFC/virtual care/cloud technologies have been developed and these vary from video conferencing to remote monitoring of patients with fragility fractures using sensors [15, 44–47] (Online Resource Table 4).

PFC effectiveness/success

Quality improvement measures for PFC programs Reports on quality improvement measures for a variety of PFC programs were identified, with recent meta-analyses published [48, 49]. For the most part, program goals, patient populations, and resources often differ among PFC programs [50–53]. Additionally, the clinical or health outcomes used to assess the success or effectiveness of PFC programs vary according to intervention type and from program to program, even for similar interventions [50–52]. However, there are some indications that the field is moving toward harmonization of quality improvement measures [13, 51, 52, 54, 55]. These quality improvement measures vary widely with many involving identification and diagnosis, others involving process, and a few involving clinically relevant long-term outcomes including mortality and rates of readmission (Fig. 4). The recent article by Javaid et al 2020 [52] reported on 11 patient-level key performance indicators (KPIs) that could be evaluated in outpatient FLSs as identified by the International Osteoporosis Foundation (IOF)'s Capture the Fracture® Campaign together with the Fragility Fracture Network (FFN) and the Bone Health and Osteoporosis Foundation (BHOF, formerly known as the National Osteoporosis Foundation [NOF]) (Fig. 4). These KPIs have been incorporated into clinical standards across regions [56–59] that are being used together with other resources to enable real-time benchmarking of the performance of FLSs. Other PFC programs that reported on KPIs include the Medicare/Medicaid program [51], the American Orthopaedic Association's (AOA's) Own the Bone program [13], the hospital-based Dutch Hip Fracture Audit program [54], and the hospital-based orthogeriatric program [55] (Fig. 4).

Of note, recent studies are now advocating the use of vertebral fracture assessments (VFAs) using spine X-ray or dual-energy X-ray absorptiometry (DXA) to identify patients with previously unidentified vertebral fractures [60–62]. The usefulness of systematic VFA was demonstrated in an FLS conducted in patients ≥ 50 years of age in which vertebral fractures that had been unknown before were identified by

VFA in 21% of patients (24 of 114 patients) [60]. A total of 18 of the 24 patients had adaptation of osteoporosis medication (16 were initiated on osteoporosis medication and 2 had osteoporosis medications intensified) because of the VFA outcome vs. 6 patients who would have received osteoporosis medication in the absence of VFA (66.7 vs. 33.3%, $P < 0.001$) [60]. In another analysis, data from the Manitoba Bone Density Program database prospective observational cohort demonstrated that targeted VFA in postmenopausal women and older men substantially improved identification of patients at high risk for fracture and was strongly associated with subsequent use of fracture prevention medication [61, 62]. The BHOF [63] and International Society for Clinical Densitometry (ISCD) [64] have both issued guidelines recommending the targeted use of VFA at the time of bone densitometry to identify patients with clinically unrecognized vertebral fracture who can be considered candidates for osteoporosis medications to prevent subsequent fragility fractures. VFA can potentially be included as an additional quality improvement measure to increase identification and treatment of patients.

Other strategies to enhance quality improvement measures of PFC programs are also being considered. These include implementation of registries, educational programs for HCPs, and new osteoporosis guidance for different medical specialties such as orthopedic surgeons and non-physicians such as nurses, physiotherapists, and nutritionists.

Comparison of FLSs and OGSs Few articles report direct comparisons between FLSs and OGSs. In a hip fracture study conducted from 2003 to 2013 at 11 hospitals in England with either FLSs or OGSs [65], both intervention types had similar reductions in 1-year mortality but no significant difference on time to a second hip fracture. In a comparison of an inpatient OGS with no outpatient follow-up vs. an inpatient OGS with an added FLS including outpatient follow-up [10], the proportion of patients on bisphosphonates was 8 vs. 10% at admission; 8 vs. 96% at discharge; and 15 vs. 75% at 6 months after discharge. Patients in the FLS could be followed-up after discharge to record adherence to treatment; most (77%) adhered to treatment at 6 months [10].

Combining FLS and OGS approaches Combining FLS and OGS approaches into a new type of program model is an emerging trend, and such programs have reported a 2- to 5-fold improvement in outcomes, including an improvement in program enrollment, osteoporosis testing and diagnosis, and initiation of osteoporosis therapy for hip fracture patients in particular [10–12, 25, 27–29, 38]. Implementation of standard orders to enroll patients who were in a geriatric hip fracture program increased FLS participation from 75 to 85.6% [12]. FLS within a hip fracture program increased rate of osteoporosis evaluation during hospitalization (0.6 to 72.6%; $P < 0.001$) and initiation of osteoporosis therapy within 3 months of discharge (25.3 to 46.3%; $P = 0.01$) [38]. In addition, an FLS-like fracture prevention service identifying hip fracture patients while still in hospital increased BMD testing from 14.5 to 47.6% and osteoporosis therapy from 17.2 to 48.5% [29]. For patients admitted to a geriatric fracture center, FLS led to a high rate of specific recommendations for osteoporosis therapy (68.6%) [25]. FLS for hip fractures with the first visit occurring in hospital increased initiation of osteoporosis therapy from 20.9 to 59.6% [27]. Adding FLS functions to a hip fracture service increased osteoporosis therapy rate from 32 to 81% [28]. Integration of an FLS with an OGS hip fracture program increased initiation of osteoporosis therapy compared with standard of care (75 vs. 15%) [10]. Integration of FLS with OGS increased basic osteoporosis therapy to 65 vs. 18% before hospitalization [11].

Initiation of osteoporosis treatment Although many hip fracture/OGS programs still do not prescribe osteoporosis therapies, those that do often prescribe the recommended osteoporosis medications for hospitalized elderly patients, including bisphosphonates (alendronate, ibandronate, risedronate, or zoledronic acid), denosumab, and teriparatide [26, 28, 66–68]. One study reported an FLS for hip fractures that started osteoporosis therapy in patients who were still hospitalized, with new initiations of osteoporosis therapy of 24.7% before FLS implementation increasing to 43.9% after FLS implementation ($P < 0.001$) [26]. Similarly, the use of an electronic order set on the day of hospital discharge improved rates of timely osteoporosis treatment following hip fracture (32 vs. 81%) [28]. A treatment algorithm for the management of osteoporosis in elderly patients during the post-operative stay in a trauma surgical ward has also been developed [66], calling for inpatient initiation of treatment with oral bisphosphonates, intravenous bisphosphonates, denosumab when bisphosphonates are contraindicated, or teriparatide if osteoporosis is severe (e.g., when vertebral body fractures occur while patient is on oral antiresorptives). Recent studies have investigated administration of zoledronic acid pre- or post-surgery in patients with vertebral compression or hip fractures [67, 68]. In general, orthogeriatric/geriatric inpatients often receive prescriptions for osteoporosis medications or FLS referrals at discharge; however, it is important to note that initiation of osteoporosis medication to inpatients may be contraindicated for several reasons, including comorbidities and vitamin D or calcium deficiency [66]. In addition, factors such as risk vs. benefit, patient adherence, and cost of medications need to be considered when making decisions for each medication [66].

Treatment adherence In general, most articles reporting on PFC quality improvement measures still do not report data

Table 5 Treatment adherence reported in articles on PFC programs published between January 2003 and December 2020

Program type	Timepoint	Adherence	Reference
FLS programs			
FLS	6 months	68% to 71%	Jia et al. Aging Clin Exp Res 2020; 32(12):2557-2564.
FLS	1 year	81.6%	Scholten et al. Arch Osteoporos 2020;15:80.
FLS	1 year	73%	Sánchez et al. J Osteoporos 2020:2020;e8208397.
FLS	1 year	99%	Makras et al. Arch Osteoporos 2020;15:12.
FLS	3–48 months	57.0% vs. 34.1% standard care (meta-analysis)	Wu et al. Bone 2018;111:92-100.
FLS	1 year	47.2%	Luc et al. Int J Environ Res Public Health 2018;15:944.
FLS	6 months	90.4%	Beaton et al. Osteoporos Int 2017;28:863-869.
FLS	1 year	56.4% vs. 54.2%	Beaton et al. Medicine 2017;96:e9012.
FLS	1 year	52%	Morell et al. Swiss Med Wkly 2017;147:w14451.
FLS	1 year	65%	Fraser et al. Aust J Rural Health 2017;25:28-33.
FLS	1 year	70%	Kim et al. N Z Med J 2016;129:50-55.
FLS	1 year	80%	Amphansap et al. Osteoporos Sarcopenia 2016;2:238-243.
FLS	3 months	78% to 79%	Shipman et al. Osteoporos Int 2016;27:3049-3056.
FLS	2 years	12.3%	Chandran et al. J Clin Densitom 2016;19:117-124.
FLS	1 year	68% vs. 67% standard care	Ruggiero et al. Clin Interv Aging 2015;10:1035-1042.
FLS	2 years	73.0%	Naranjo et al. Osteoporos Int 2015;26:2579-2585.
FLS	2 years	~ 50%	Ganda et al. Osteoporos Int 2014;25:1345-1355.
OGS or hip fracture care			
Hip fracture patients	120 days	33%	Cehic et al. Bone Joint J 2019;101-B:1402-1407.
Geriatric hip fracture	1 year	35%	Gamboa et al. Osteoporos Int 2018;29:2309-2314.
Geriatric fracture FLS	NA	32.8% vs. 34.2% standard care	Heyman et al. Osteoporos Sarcopenia 2018;4:134-139.
FLS and OGS or hip fracture care			
Geriatric hip fracture FLS	1 year	40.2%	Park et al. J Bone Metab 2018;25:107-113.
Other			
FLS vs. education	2 years	67% in education group patients vs. 53% in case managed patients	McAlister et al. Osteoporos Int 2019;30:127-134.
National database	> 6 months, > 12 months	53.6%, 33.9% teriparatide	Chan et al. Osteoporos Int 2016;27:2855-2865.
NA	1, 2 years	53.8%, 68.5%	Hsu et al. J Bone Miner Metab 2015;33:577-583.

FLS, fracture liaison service; *OGS*, orthogeriatric service; *PFC*, post-fracture care; *NA*, not applicable

on treatment adherence to osteoporosis therapy. For those that do, there is evidence of heterogeneity in most reports with regard to patient populations, timepoints for assessments, sample sizes, and program designs when evaluating adherence (Table 5). Generally, there is lower adherence to osteoporosis therapy in orthogeriatric/geriatric fracture patients, with little or no adherence reporting for OGSs with no FLS functions. Most osteoporosis treatments show

Table 6 Articles on PFC programs published between January 2003 and December 2020 per country population size

Country	Number of PFC articles	Population[a]	Osteoporosis prevalence(per 10,000)[b]	Key reference with country-specific data on osteoporosis prevalence (if available)
High PFC activity (per population size)				
United States	152	329,064,917	330	Wright et al. J Bone Miner Res 2014;29:2520-2526.
United Kingdom	91	67,530,172	511	Svedbom et al. Arch Osteoporos 2013;8:137.
Canada	94	37,411,047	546	
Australia	47	25,203,198	484	Australian Institute of Health and Welfare
Netherlands	37	17,097,130	480	Svedbom et al. Arch Osteoporos 2013;8:137
Italy	32	60,550,075	638	Svedbom et al. Arch Osteoporos 2013;8:137
Spain	26	46,736,776	529	Svedbom et al. Arch Osteoporos 2013;8:137.
France	25	65,129,728	536	Svedbom et al. Arch Osteoporos 2013;8:137.
South Korea	21	51,225,308	~1700	Park et al. Yonsei Med J 2014;55:1049-1057.
Denmark	19	5,771,876	488	Svedbom et al. Arch Osteoporos 2013;8:137.
Taiwan	18	23,773,876	739	Chen et al. Biomed J 2018;41:314-320.
Norway	16	5,378,857	565	Norwegian Institute of Public Health
Ireland	14	4,882,495	357	Svedbom et al. Arch Osteoporos 2013;8:137.
Switzerland	13	8,591,365	541	Svedbom et al. Arch Osteoporos 2014;9:187.
Sweden	13	10,036,379	525	Svedbom et al. Arch Osteoporos 2013;8:137.
Singapore	12	5,804,337	NF	
Austria	11	8,955,102	527	Svedbom et al. Arch Osteoporos 2013;8:137.
Israel	9	8,519,377	NF	
New Zealand	7	4,783,063	NF	
Finland	5	5,532,156	543	Svedbom et al. Arch Osteoporos 2013;8:137.
Lebanon	3	6,855,713	NF	
Slovenia	1	2,078,654	529	Svedbom et al. Arch Osteoporos 2013;8:137.
Low PFC activity (per population size)				
Germany	27	83,517,045	611	Svedbom et al. Arch Osteoporos 2013;8:137.
China	23	1,433,783,686	492	International Osteoporosis Foundation
Japan	14	126,860,301	941	International Osteoporosis Foundation
Thailand	6	69,037,513	NF	
India	5	1,366,417,754	~373	Malhotra et al. Indian J Med Res 2008;127:263-268.
Greece	4	10,473,455	573	Svedbom et al. Arch Osteoporos 2013;8:137.
Belgium	4	11,539,328	525	Svedbom et al. Arch Osteoporos 2013;8:137.
Poland	3	37,887,768	485	Svedbom et al. Arch Osteoporos 2013;8:137.
Czech Republic	2	10,689,209	499	Svedbom et al. Arch Osteoporos 2013;8:137.
Colombia	2	50,339,443	NF	
Saudi Arabia	2	34,268,528	NF	
South Africa	2	58,558,270	NF	
Chile	1	18,952,038	NF	
Egypt	1	100,388,073	NF	
Lithuania	1	2,759,627	NF	
Malaysia	1	31,949,777	NF	
Mexico	1	127,575,529	NF	
Pakistan	1	216,565,318	NF	
Portugal	1	10,226,187	573	Svedbom et al. Arch Osteoporos 2013;8:137.
Russia	1	145,872,256	NF	
Sri Lanka	1	21,323,733	NF	
Turkey	1	83,429,615	NF	
Multinational	34	NA		

[a]Data source: Wikipedia. List of countries by population (United Nations). Per United Nations estimates for July 1, 2019 (current version)

[b]Estimate based on adults ≥ 50 years/total population for all countries except for Canada and Japan; Canada and Japan estimates based on total population with osteoporosis/total population

NA, not applicable; *NF*, not found; *PFC*, post-fracture care anti-fracture efficacy between 12 and 18 months for vertebral fractures. As such, monitoring adherence to osteoporosis therapy at 3, 6, or 9 months may best serve as an interim KPI for vertebral fractures but adherence at ≥ 12 months would be preferred.

Impact of COVID-19 on PFC Thirteen articles reported on COVID-19 in the context of PFC programs with some articles reporting on process adaptations that could facilitate PFC during the pandemic, while others reported on the specific impact of COVID-19 on PFC delivery. Details of identified studies are provided in Online Resource 1, under the subheading of Studies on Impact of COVID-19 on PFC.

PFC geography

Adoption of PFC programs has been occurring in previously unserved regions and countries, and expansion of PFC availability has also been reported in regions and countries with established PFC programs (Table 6). There have been some reports of new PFC programs since 2019, with a recent trend toward more expansion of OGS. New reports have been published on hip fracture programs in several countries including mainland China, Israel, South Africa, and the USA; on FLSs in several countries including South Korea, Thailand, Canada, and Germany; and on treatment rates or disease burden in several countries including Japan, mainland China, Denmark, and the UK (Table 6). However, some countries with a high osteoporosis incidence produced few or no PFC publications over the period studied (Table 6). It is noteworthy to acknowledge that lack of publications may not necessarily reflect an ongoing global osteoporosis care gap; however, this might reflect the low awareness of the need for osteoporosis care programs even in developed countries with established PFC programs.

Open questions still remain in most geographic regions, especially with regard to the impact of healthcare system types that tend to vary from country to country (i.e., open or closed, public or private). Additionally, in countries with less developed healthcare infrastructure, long distances to a clinic or health facility may result in patients being lost to follow-up [69], hence diminishing the effectiveness of PFC care. More information on virtual care is required, especially with respect to the COVID-19 pandemic and its impact on rates of follow-up and treatment patterns.

PFC economics

There has been an increase in publications reporting on PFC economics since 2017. PFC programs are generally cost-effective, but there is a high degree of variability in cost-effectiveness given the heterogeneity in resourcing, PFC structures, and outcomes being measured. We identified reports that compared costs of FLSs with costs of standard of care [27, 70], costs between different FLSs [71], costs of OGS/hip fracture programs vs. standard of care [72], reimbursement related to PFC programs [72–74], and socioeconomic status and financial considerations [75, 76]. Details of the identified studies are provided in Online Results 1, under the subheading of Studies on PFC Economics.

Overall, most identified articles demonstrated that PFC programs were generally cost-effective and reduced the economic cost of subsequent fragility fractures for both the individual and the society. Of note, the identified publications reported economic outcomes differently. As such, comparisons may need to focus on cost savings per patient. Most articles factored in only direct costs in assessing the economic cost of subsequent fragility fractures; indirect costs such as lost productivity were not factored in cost assessments even though they can be quite substantial.

Barriers to PFC

A few articles have reported on challenges hindering provision of adequate care to patients to prevent subsequent fractures. Barriers include significant increase of workload to healthcare systems [77], inability by HCPs to identify patients at risk and follow-up with appropriate referrals [78], failure by patients to follow-up on scheduled tests such as DXA scans [79], and patients' perspectives on the need for osteoporosis medications [80].

In our view, the main barrier to secondary fracture prevention is likely the lack of adequate information on the part of population healthcare decision-makers, HCPs, and patients on the nature of osteoporosis as an underlying chronic disease that puts patients at risk for fragility fractures and that can be costly to patients, to their caregivers, and to society at large. Population health decision-makers are often unaware of the impact of fragility fractures, and yet are usually involved in evaluating the business case for establishing PFC programs. HCPs may not assess, diagnose, and treat patients at risk for osteoporosis and fragility fracture due to numerous reasons including time constraints, insufficient knowledge, competing priorities, doubts about effectiveness of osteoporosis treatments, and fear of adverse events. At the service provider level, the lack of knowledge might be reflected in poor patient identification, lack of adequate provider communications regarding patient care, inadequate record keeping/data management/electronic notifications, and poor quality control. Therefore, HCPs may not recognize fragility fractures, assess osteoporosis risk, and prescribe treatment in situations that may warrant it. At the patient level, patients may not feel the need to follow-up with their HCPs regarding osteoporosis care following a primary fracture due to a lack of clarity around what actions to take or denial that occurrence of a primary fracture puts them at increased risk of subsequent fractures. Patients may also be unwilling or have limited ability to participate in PFC programs due to the time required for follow-up visits, out-of-pocket expenses, and frailty.

Facilitating adoption and implementation of PFC programs

Establishment of new PFC programs is required, including expansion to rural and remote areas, to enhance equity of care for patients with osteoporosis. Many medical societies offer educational resources and counsel to help providers establish PFC programs. These include the IOF Capture the Fracture, the IOF PFC resource center, BHOF FLS resources, BHOF FLS coding guide, AOA's Own the Bone, American Geriatrics Society (AGS)'s CoCare model, and the FFN Clinical and Policy Toolkits. There is an opportunity to develop clinical guidelines that recommend specific actions and frameworks for different models of care and also provide education to HCPs, including e-learning. Another strategy is to motivate providers through cultivating local champions, providing financial incentives, and tracking and publishing performance data. An additional way is through coordination of efforts across fracture coordinators, including sharing of best practices through collaboration platforms such as the Extension for Community Healthcare Outcomes (ECHO), and cooperation among multiple specialties. For rural or remote regions with low population densities or limited resources, adoption of remote digital programs and models that require fewer staff might aid in the establishment of PFC programs.

Sustainability of programs, especially after a PFC provider champion departs, is a recognized challenge. Hence, PFC programs need to be an integral part of healthcare systems, with the PFC protocols or program framework deeply embedded into the hospital/clinic practice (e.g., updating EHR practices and establishing a protocol for ensuring connectivity across providers). This will help to make these programs champion independent, to ensure long-term sustainability.

Summary

There is an increasing awareness of the importance of PFC programs in overall patient care, with the number of PFC-related publications increasing yearly from 2003 to 2020. However, a publication gap still remains in several countries, including those countries with a reported high incidence of fragility and/or hip fractures. Factors contributing to the observed publication gap may be a reflection of priorities and/or limited resources of institutions and research groups. These factors are likely impacted by geography and socioeconomic status but further research is required to provide more information.

From our literature search and assessment of the available PFC-related publications, we found that continued implementation of FLS and OGS programs is important in managing osteoporosis, with programs that combine both FLS and OGS functions becoming more common [10–12, 25–38]. Combining FLS and OGS approaches appears to result in about 2- to 5-times improvement in outcome measures such as program enrollment, osteoporosis testing and diagnosis, and initiation of osteoporosis therapy [10–12, 25–29, 38]. Success of these programs requires ongoing research into quality improvement measures and best practices, new treatment approaches, and expansion of programs to include elderly patients, different fracture types, and patients with comorbidities. Articles on orthogeriatric and hip fracture care still have a stronger focus on survival and comorbidities rather than on refracture rates. It appears there is a trend toward the treatment of elderly patients and in the diagnosis and treatment of vertebral fractures [81]. Recent publications suggest that once PFC programs are established, there is a desire to expand and refine their practices as well as to optimize cost-effectiveness.

The success and effectiveness of PFC programs is well documented; however, areas for improvement still exist. In general, there is inconsistent reporting of clinical or health outcomes, even for similar interventions; program goals, patient populations, and resources are often different among PFC programs [50–53]. Patient adherence to osteoporosis medications varies, with interventions that include prescribing osteoporosis medications often showing improved patient outcomes but not to optimal levels. Inconsistent reporting of quality improvement measures is still a key challenge, but there is now evidence of some efforts at harmonizing quality improvement measures for PFC programs [13, 51, 52, 54, 55].

Other factors that could contribute to successful PFC programs have been identified including implementation of registries, educational programs, and continuous updates of osteoporosis guidance for HCPs. The AOA's Own the Bone program [13] is a multicenter voluntary fragility US registry created in 2009 and functions as an externally validated cohort for studying fragility fractures in patients. The program has been used to define quality improvement measures [13] and is credited with successfully improving the behaviors of medical professionals with regard to osteoporosis treatment and managing patients with fragility fractures [82]. An independent registry [14] showed an increase in identification of patients with fractures who are ≥ 50 years from 0 to 74.5% as a result of registry implementation, with 33.9% of those identified patients proceeding to have screenings and follow-up visits. Additionally, the Hip Fracture Registry Toolbox [83] provides a distillation of information from existing national registries and practical advice on starting new registries.

For the educational programs, the Bone Health Extension for Community Healthcare Outcomes (TeleECHO) was established in the USA to use video conferencing technology to provide education on the care of patients with skeletal diseases to HCPs in communities, including those in rural and underserved areas [17]. The TeleECHO initiative has been used by US- and international-based HCPs and is a model that could be replicated to include the education of FLS coordinators and other HCPs to expand the pool of specialists who can provide bone healthcare to patients [17]. A number of organizations across the globe are now hosting Bone Health TeleECHO programs including the BHOF and the AOA.

For osteoporosis therapy, there is variability in treatment approaches across PFC programs; however, many emerging guidelines would consider individuals with a recent fracture or history of multiple fractures to be at very high risk for future fracture and appropriate for treatment with an anabolic agent [84–87]. Anabolic therapy should be followed by antiresorptive therapy to preserve BMD gains obtained while on an anabolic, and reassessment is recommended every 1 to 2 years [85] or after a fracture [86].

Reports have been published on the impact of COVID-19 on PFC delivery [88]. Of note, there is an opportunity to take lessons learned during the COVID-19 pandemic and implement them to patient care, particularly in rural or remote areas with limited access to patient care. This could include increased use of telemedicine and virtual technology.

With regard to geographic variation, there is evidence that PFC programs continue to expand into new and underserved regions and countries, and also to increase in countries with established PFC programs. The trend seems to be toward OGS programs. There is still a care gap even in developed countries with established PFC programs. Issues of consideration in different regions include the impact of healthcare system types and proximity to clinics or healthcare facilities, especially in countries with less developed healthcare infrastructure.

There has been an increase in reports on the economics of PFC programs since 2017, and these show that PFC programs are cost-effective [49, 70, 72]. High-intensity interventions such as Type A FLSs are more costly but are generally cost-effective or even cost-saving [27, 71]. There is evidence that reimbursement may be a bigger driver of funding decisions than quality of care [72, 73]; only 1 study from Japan showed no reduction in healthcare resource utilization linked to financial incentives for regionally coordinated hip care [74]. Data are available comparing PFC programs to standard of care [49, 70, 72], with only limited data comparing economics of FLSs and OGSs. New data on PFC implementation or maintenance costs are not readily available, limiting the ability to properly evaluate costs associated with these programs. There is still inconsistent reporting of economic outcomes. Not all studies report incremental cost-effectiveness ratios or quality-adjusted life-years, and it may be more helpful to focus on cost or cost savings per patient. In assessing the economic cost of subsequent fragility fractures, most articles do not factor in indirect costs such as lost productivity, even though these costs are generally considered substantial.

Lack of information is the main barrier to prevention of subsequent fracture, and this can be addressed by educating population healthcare decision-makers, HCPs, and patients to understand the personal and societal burden of osteoporosis. Adoption and implementation of PFC programs can be facilitated through various resources from key organizations including the IOF, BHOF, AOA, and AGS. Sustainability of PFC programs can be achieved by integrating processes into hospital and clinic practices.

Of all the information garnered from the literature search and assessment of publications on PFC programs, we believe combining FLS and OGS approaches together with development of fragility fracture registries to provide ongoing research to advance KPIs could improve the effects of PFC programs the most. Combining FLS and OGS approaches has been shown to result in improvement in outcome measures such as program enrollment, osteoporosis testing and diagnosis, and initiation of osteoporosis therapy. The ongoing research from the combined FLS/OGS programs and/or the fragility fracture registries could inform new strategies for improving quality improvement measures and best practices, incorporating new treatment approaches, and expanding programs to include elderly patients, different fracture types, and patients with comorbidities. Additionally, we believe that high-level policy change, requiring secondary fracture prevention to be an integral part of standard patient care, could facilitate financial support including reimbursement and personnel for implementation of more of these important programs.

The main strength of our literature search and assessment is that it provides a cross-sectional snapshot of the global landscape of PFC programs. However, a number of limitations should be considered. First, the main focus of PFC programs is patient care and most settings may not view publishing quality improvement measures of these programs as valuable; thus, findings from our literature search may not fully represent the available knowledge and progress on PFC programs to date. Second, since the literature search was based on relevance to PFC programs, there may be some bias in that all authors publishing may have already convinced their healthcare centers that fracture risk is an issue worth identifying, evaluating, and managing; however, a significant proportion of health centers may still not view fracture risk as an issue and may not allocate resources to fracture prevention, thus leaving patients at risk for new fractures. Third, to date, most FLSs and OGSs focus on the elderly in hospital settings; there is limited information on programs for younger patients with fractures or elderly patients in assisted-living facilities who experience fractures.

In conclusion, there has been a marked increase in the number of publications describing how PFC programs can improve investigation and treatment rates for osteoporosis. However, there is a publication gap in several countries including those countries with a reported high incidence of fragility and/or hip fractures. The most common models of PFC programs are FLSs and OGSs, and these have been shown to be cost-effective. Improvements in established PFC programs are still needed to standardize patient identification and outcomes reporting. Additionally, establishment of new PFC programs is required, including expansion to rural and remote areas, to enhance equity of care for patients with fracture and osteoporosis, to prevent occurrence of subsequent fractures.

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Data availability Qualified researchers may request data from Amgen clinical studies. Complete details are available at the following: https://wwwext.amgen.com/science/clinical-trials/clinical-data-transparency-practices/clinical-trial-data-sharing-request/.

Code availability Not applicable.

Declarations

Ethics approval Not applicable.

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Conflict of interest Kristina E. Åkesson is a consultant for Amgen, Renapharma, and UCB Pharma and is on the speakers' bureau for Amgen. Kirtan Ganda has nothing to disclose. Cynthia Deignan is an employee and stockholder of Amgen. Mary K. Oates is an employee and stockholder of Amgen. Amy Volpert is an employee of BioScience Communications, which received funding from Amgen for this project. Keyla Brooks is an employee and stockholder of UCB Pharma. David Lee is a former employee and stockholder of Amgen and is currently an employee of Health Collaboration Partners LLC, a healthcare consulting firm. Douglas R. Dirschl is a consultant for Stryker, BONE-SUPPORT, SI-BONE, and Acumed. Andrea J. Singer has received research support from Radius and UCB Pharma; is a consultant for AgNovos, Amgen, Radius, and UCB Pharma; and is on the speakers' bureau for Amgen and Radius.

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