

Review Article

Fracture Liaison Services and Secondary Fracture Prevention in Fragility Fracture Patients

Keller K^{1*}, Byrne C² and Sundberg G³¹Department of Orthopaedic Surgery, University of Heidelberg, Heidelberg, Germany²Department of Rheumatology, University College Dublin, Dublin, Ireland³Department of Geriatric Medicine, Karolinska Institute, Stockholm, Sweden

*Address for Correspondence: Katrin Keller, Department of Orthopaedic Surgery, University of Heidelberg, Heidelberg, Germany; E-mail: katrin.keller@universityofheidelberg.edu

Received: 18 January 2026; Accepted: 1 May 2026; Published: 26 July 2026; DOI: [10.5281/zenodo.22328032](https://doi.org/10.5281/zenodo.22328032)

Citation of this article: Keller K, Byrne C, Sundberg G (2026) Fracture Liaison Services and Secondary Fracture Prevention in Fragility Fracture Patients. Int J Orthop, 7(1): 01-06.

Copyright: © 2026 Katrin Keller, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

Background: Fragility fractures predict further fractures and death, yet most patients never receive osteoporosis investigation or treatment after an index fracture.

Objective: To synthesise evidence on fracture liaison service (FLS) models and their effect on osteoporosis investigation, treatment initiation, secondary fracture incidence, mortality, and cost-effectiveness.

Methods: Narrative review of systematic reviews, meta-analyses, randomised trials, registry audits, and health-economic studies.

Findings: Coordinator-led "Type A" FLS models most reliably increase bone mineral density testing and treatment initiation, and are associated with an approximately 30-46% relative reduction in subsequent fracture and modest mortality benefit. Return on investment averages roughly ten-fold, and cost per quality-adjusted life-year gained falls well below conventional thresholds across health systems. Adherence beyond twelve months and regional implementation remain uneven.

Conclusions: FLS represent the most consistently effective secondary-prevention strategy for fragility fracture, though long-term persistence and global coverage require continued investment.

Keywords: Fracture liaison service; Secondary fracture prevention; Fragility fracture; Osteoporosis treatment gap; Capture the Fracture

Abstract

Background: Fragility fractures predict further fractures and death, yet most patients never receive osteoporosis investigation or treatment after an index fracture.

Objective: To synthesise evidence on fracture liaison service (FLS) models and their effect on osteoporosis investigation, treatment initiation, secondary fracture incidence, mortality, and cost-effectiveness. **Methods:** Narrative review of systematic reviews, meta-analyses, randomised trials, registry audits, and health-economic studies. **Findings:** Coordinator-led "Type A" FLS models most reliably increase bone mineral density testing and treatment initiation, and are associated with an approximately 30-46% relative reduction in subsequent fracture and modest mortality benefit. Return on investment averages roughly ten-fold, and cost per quality-adjusted life-year gained falls well below conventional thresholds across health systems. Adherence beyond twelve months and regional implementation remain uneven. **Conclusions:** FLS represent the most consistently effective secondary-prevention strategy for fragility fracture, though long-term persistence and global coverage require continued investment.

Keywords: fracture liaison service; secondary fracture prevention; fragility fracture; osteoporosis treatment gap; Capture the Fracture

Introduction

Osteoporotic fragility fractures affect an estimated 3.5 million people annually in the European Union alone, comprising 610,000 hip, 520,000 vertebral, 560,000 forearm, and 1.8 million other fractures, with an economic burden of 37 billion in 2010 that is projected to rise by a further 25% by 2025 as populations age [1]. A prior low-trauma fracture roughly doubles the hazard of subsequent fracture and of death within the following five to ten years, with mortality hazard ratios of 1.91 in women and 2.99 in men after a second fracture [2]. Risk is highest

in the immediate post-fracture period: pooled worldwide data spanning multiple cohorts show a 7.6% incidence of a further "imminent" fracture within one year and 11.6% within two years of the index event, a window during which intervention has the greatest theoretical yield [3]. Despite this well-characterised risk, national registry data consistently show that most patients are neither investigated nor treated for the underlying bone disease that caused their fracture: in Denmark, roughly 79% of patients with a major osteoporotic fracture remained untreated one year later, a proportion that had improved only modestly from 85% a decade earlier, and vertebral fractures — the most common and most under-recognised osteoporotic fracture — are missed on routine imaging in 29-46% of cases worldwide [4,5]. This persistent "secondary prevention gap," in which orthopaedic teams treat the fracture but no clinician assumes responsibility for the underlying skeletal fragility, prompted development of the fracture liaison service (FLS) model, in which a dedicated coordinator systematically identifies fracture patients, arranges fracture-risk assessment, and facilitates treatment initiation and long-term follow-up across the orthopaedic-primary care interface [6]. This review synthesises evidence on FLS service models, their effect on investigation and treatment rates, subsequent fracture and mortality outcomes, cost-effectiveness, and remaining implementation barriers, drawing on systematic reviews, randomised trials, national registries, and health-economic analyses.

FLS Models and the Capture the Fracture Framework

A systematic review and meta-analysis of 42 studies classified secondary-prevention services into four models of increasing intensity: Type A programmes identify, assess, and initiate treatment directly; Type B identify and assess but refer treatment decisions elsewhere; Type C

alert clinicians without direct patient assessment; and Type D provide education alone (Table 1) [7]. Meta-regression showed a graded relationship between intervention intensity and both bone mineral density (BMD) testing and treatment initiation, with fully coordinated Type A and B models proving the most clinically effective and cost-effective, while alert- or education-only approaches produced comparatively small, often non-significant gains [7]. This taxonomy has become the organising framework for the field, informing trial design and international guidance on the intensity of intervention required. The International Osteoporosis Foundation's Capture the Fracture programme operationalised this evidence into a 13-standard Best Practice Framework spanning inclusive case-finding, evidence-based risk assessment, guideline-concordant treatment initiation, and long-term adherence monitoring across hip, inpatient, outpatient, and vertebral fracture pathways, awarding Bronze, Silver, or Gold recognition to participating services [8]. Benchmarking of the first 60 participating hospitals across six continents, serving catchment populations from 20,000 to 15 million people, found marked heterogeneity, with hip-fracture pathways achieving gold status far more often than vertebral-fracture pathways, underscoring uneven implementation even among committed services with institutional buy-in [9]. Regional consensus standards have since been adapted for the Asia-Pacific region to reflect differing healthcare financing and referral structures, where systematic review of 37 studies identified persistent unmet needs in public funding, dedicated coordinator staffing, and cross-specialty coordination despite a rapidly rising regional fracture incidence [10,11].

Table 1: Models of care for secondary fracture prevention, classified by intervention intensity [7,8].

Model type	Case-finding	Risk assessment	Treatment initiation	Relative effectiveness
Type A	Yes	Yes, by service	Directly initiated by service	Highest; most cost-effective
Type B	Yes	Yes, by service	Referred to primary/specialist care	High; cost-effective
Type C	Yes	Alert only, no direct assessment	Left to alerted clinician	Moderate
Type D	Patient education only	No	No	Lowest

Effect on Osteoporosis Investigation and Treatment Initiation

Randomised evidence directly supports coordinator-led models. A Canadian trial randomising hip-fracture patients to a dedicated case manager versus usual care substantially increased BMD testing and treatment initiation within six months of fracture compared with the physician-notification control arm [12], and a companion controlled trial in wrist-fracture patients replicated this effect, with the improvement in osteoporosis investigation and treatment proving both durable at extended follow-up and cost-effective relative to usual outpatient care [13]. Together these trials provided early high-quality randomised evidence that a dedicated coordinator, rather than passive physician education alone, drives improved secondary-prevention care. A systematic review of 57 FLS studies drawn from over 7,000 screened citations confirmed these trial findings at scale, reporting an approximate 27% absolute increase in BMD testing and up to 21% increase in treatment initiation compared with usual care, with multidisciplinary coordination, dedicated case management, and structured follow-up identified as the key success factors distinguishing high-performing from low-performing services [14]. Real-world registry data illustrate both the achievement and the ceiling of these gains: the UK's national FLS Database, now covering nearly 500,000 patient records across England, Wales, and

Northern Ireland, reported that an increasing majority of participating services achieve non-vertebral case-finding rates above 80%, yet DXA turnaround times and structured monitoring showed little improvement between successive audit cycles, indicating that case identification has outpaced downstream assessment and follow-up capacity in many services [15].

Effect on Secondary Fracture Incidence and Mortality

Effect on hard clinical outcomes has been confirmed across multiple pooled analyses (Figure 1). A meta-analysis of nine comparisons across eight studies found FLS care associated with significantly lower odds of subsequent fracture (odds ratio 0.70), an effect that strengthened to 0.57 for follow-up periods exceeding two years but was not detectable in studies with shorter follow-up, while overall mortality reduction was not significant across all comparisons and reached significance only in pre-post cohort comparisons (odds ratio 0.65), with hospital-based concurrent-control comparisons showing no mortality effect [16]. A Swedish minimal-resource FLS cohort, deliberately designed to test whether benefit required intensive staffing, found a 51% relative reduction in re-fracture among treated patients (hazard ratio 0.49) and a significantly lower re-fracture rate even in the oldest patients aged 80 years and above [17], while a Spanish prospective cohort of elderly hip-fracture patients found a 34% reduction in one-year mortality among those started on anti-osteoporosis medication through an FLS (adjusted hazard ratio 0.66) [18]. A 2025 meta-analysis restricted specifically to femoral-fracture FLS cohorts, pooling 14 studies addressing subsequent fracture and 18 addressing mortality, found a 46% lower risk of subsequent fracture (risk ratio 0.54) and a non-significant 17% lower mortality risk (risk ratio 0.83) [19]. Across these analyses the fracture-reduction signal is consistent, of a similar

magnitude across markedly different healthcare systems, and often statistically robust, whereas the mortality benefit is smaller, less consistent, and more dependent on study design, plausibly reflecting confounding by indication, since patients who accept, tolerate, and remain on treatment differ systematically in overall health and frailty from those who do not.

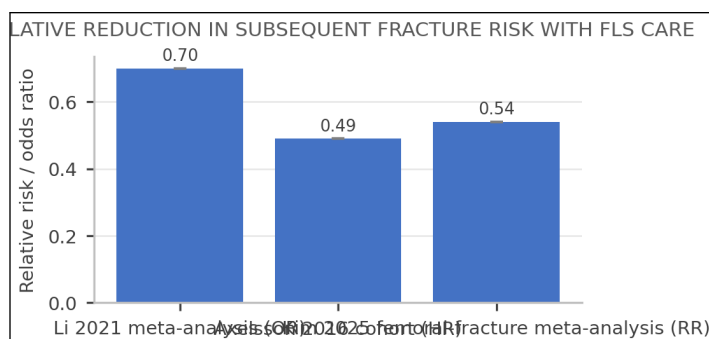


Figure 1: Relative risk of subsequent fracture in patients managed through a fracture liaison service versus usual care, from three independent pooled or cohort analyses [16,17,19].

Cost-Effectiveness and Return on Investment

Economic evaluation broadly supports FLS implementation across highly divergent health systems (Figure 2, Table 2). A systematic review of 23 economic studies, comprising 16 cost-effectiveness analyses, two cost-benefit analyses, and five cost-savings studies, found FLS cost-effective or cost-saving in every health system examined, with cost per quality-adjusted life-year (QALY) ranging from roughly \$3,000 in Japan to under \$115,000 in the United States, both comfortably within their respective accepted willingness-to-pay thresholds [20]. UK data collected over eight years of routine service provision projected that FLS implementation would prevent 18 fractures, including 11 hip fractures, per 1,000 patients evaluated, generating a net saving of £21,000 despite an estimated national implementation cost of £9.7 million, a favourable balance that supported national commissioning guidance [21]. A Spanish decision-analytic model reported an incremental cost-utility ratio of 6,855

per QALY gained over a ten-year horizon, again well below the 20,000- 30,000 threshold conventionally applied in that setting [22]. A pooled analysis of 23 FLS evaluations across multiple countries found a mean return on investment of 10.49-fold, rising to 18.39-fold for services that issued explicit treatment recommendations to referring clinicians and 12.07-fold for those led by primary care providers rather than hospital specialists, with 87% of evaluated services showing a positive return on the resources invested [23]. These analyses indicate that the economic case for FLS is not confined to any single funding model or health system.

Table 2: Selected studies quantifying the clinical and economic impact of fracture liaison services reviewed here [12,13,17,18,16,19,21,22].			
Study	Design	Population	Key outcome
Majumdar 2007 (hip)	RCT	Hip fracture	Increased BMD testing and treatment initiation with case manager
Majumdar 2007 (wrist)	Controlled trial	Wrist fracture	Sustained, cost-effective improvement in osteoporosis care
Axelsson 2016	Cohort	Mixed fragility fracture	51% lower re-fracture risk with treatment (HR 0.49)
Gonzalez-Quevedo 2020	Prospective cohort	Hip fracture, elderly	34% lower 1-year mortality with treatment (aHR 0.66)
Li 2021	Meta-analysis	Mixed fragility fracture	Subsequent fracture OR 0.70; mortality OR 0.65 (pre-post)
Kim 2025	Meta-analysis	Femoral fracture	Subsequent fracture RR 0.54; mortality RR 0.83 (ns)
McLellan 2011	Cost-effectiveness, 8-year data	Mixed fragility fracture	18 fractures prevented, GBP 21,000 saved per 1,000 patients

Study	Design	Population	Key outcome
Naranjo 2022	Cost-utility model	Mixed fragility fracture, Spain	EUR 6,855 per QALY gained over 10 years

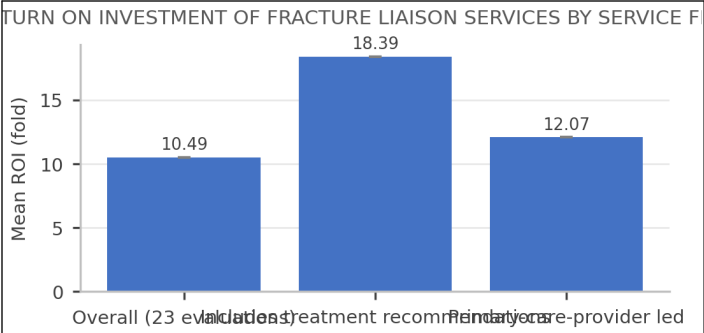


Figure 2: Mean return on investment of fracture liaison services overall and by service feature, from a systematic review and analysis of 23 economic evaluations [23].

Barriers, Adherence, and Implementation Gaps

Benefit realisation depends on sustained patient engagement well beyond the index encounter, and this remains the weakest link in most services. A French cohort found that roughly half of FLS-enrolled patients over 70 did not complete their scheduled follow-up visits, with failure to initiate treatment at the first visit the strongest independent predictor of subsequent non-adherence, whereas neither advanced age nor frailty predicted disengagement, challenging assumptions that older or frailer patients are inherently less able to participate [24]. FRAX-based absolute fracture-risk stratification, now embedded in most best-practice pathways, helps coordinators prioritise limited resources toward the patients at highest absolute risk of a further fracture rather than treating all fracture patients uniformly [25]. Beyond patient-level adherence, service-level variation remains substantial: the Capture the Fracture benchmarking data show that even Gold-rated services in high-income settings struggle to achieve consistent vertebral-fracture case-finding, and the Asia-Pacific experience shows that funding, staffing, and reimbursement structures — rather than clinical evidence — are now the principal barriers to

scale-up in many health systems [9,10]. Editorial commentary on the field's trajectory argues that the next priority is standardising outcome reporting across services and registries and extending coordinator-led models beyond the well-resourced settings in which most of the randomised and cost-effectiveness evidence was generated [26].

Conclusion

Fracture liaison services, particularly fully coordinated models that combine case-finding, risk assessment, and direct treatment initiation, remain the best-evidenced strategy for closing the secondary fracture prevention gap. They increase investigation and treatment rates, reduce subsequent fracture risk by roughly a third to a half across pooled analyses, show more modest but real mortality benefit in some cohorts, and are consistently cost-effective or cost-saving. The principal remaining challenges are long-term adherence beyond the first year and equitable global implementation, particularly outside the high-resource settings where the framework was developed and validated.

References

1. Hernlund, E., Svedbom, A., Ivergård, M., Compston, J., Cooper, C., Stenmark, J., McCloskey, E.V., Jönsson, B., Kanis, J.A. (2013) Osteoporosis in the European Union: medical management, epidemiology and economic burden. *Archives of Osteoporosis*, 8(1): 136.
2. Bliuc, D., Nguyen, N.D., Milch, V.E., Nguyen, T.V., Eisman, J.A., Center, J.R. (2009) Mortality risk associated with low-trauma osteoporotic fracture and subsequent fracture in men and women. *JAMA*, 301(5): 513-521.
3. Wong, R.M.Y., Wong, P.Y., Liu, C., Wong, H.W., Chung, Y.L., Chow, S.K.H., Cheung, W.H. (2022) The imminent risk of a fracture-existing worldwide data: a systematic review and meta-analysis. *Osteoporosis International*, 33(12): 2453-2466.
4. Skjødt, M.K., Ernst, M.T., Khalid, S., Libanati, C., Cooper, C., Delmestri, A., Cooper, A., Javaid, M.K., Prieto-Alhambra, D., Abrahamsen, B. (2021) The treatment gap after major osteoporotic fractures in Denmark 2005-2014: a combined analysis including both prescription-based and hospital-administered anti-osteoporosis medications. *Osteoporosis International*, 32(10): 1961-1971.
5. Delmas, P.D., van de Langerijt, L., Watts, N.B., Eastell, R., Genant, H., Grauer, A., Cahall, D.L. (2005) Underdiagnosis of vertebral fractures is a worldwide problem: the IMPACT study. *Journal of Bone and Mineral Research*, 20(4): 557-563.
6. Marsh, D., Åkesson, K., Beaton, D.E., Bogoch, E.R., Boonen, S., Brandi, M.-L., McLellan, A.R., Mitchell, P.J., Sale, J.E.M., Wahl, D.A. (2011) Coordinator-based systems for secondary prevention in fragility fracture patients. *Osteoporosis International*, 22(7): 2051-2065.
7. Ganda, K., Puech, M., Chen, J.S., Speerin, R., Bleasel, J., Center, J.R., Eisman, J.A., March, L., Seibel, M.J. (2013) Models of care for the secondary prevention of osteoporotic fractures: a systematic review and meta-analysis. *Osteoporosis International*, 24(2): 393-406.
8. Åkesson, K., Marsh, D., Mitchell, P.J., McLellan, A.R., Stenmark, J., Pierroz, D.D., Kyer, C., Cooper, C. (2013) Capture the Fracture: a Best Practice Framework and global campaign to break the fragility fracture cycle. *Osteoporosis International*, 24(8): 2135-2152.
9. Javaid, M.K., Kyer, C., Mitchell, P.J., Chana, J., Moss, C., Edwards, M.H., McLellan, A.R., Stenmark, J., Pierroz, D.D., Schneider, M.C., Kannegaard, P., Åkesson, K., Cooper, C. (2015) Effective secondary fracture prevention: implementation of a global benchmarking of clinical quality using the IOF Capture the Fracture Best Practice Framework tool. *Osteoporosis International*, 26(11): 2573-2578.

10. Chang, Y.-F., Huang, C.-F., Hwang, J.-S., Kuo, J.-F., Lin, K.-M., Huang, H.-C., Bagga, S., Kumar, A., Chen, F.-P., Wu, C.-H. (2018) Fracture liaison services for osteoporosis in the Asia-Pacific region: current unmet needs and systematic literature review. *Osteoporosis International*, 29(4): 779-792.
11. Chan, D.C., Chang, L.Y., Akesson, K.E., Mitchell, P., Chen, C.H., Lewiecki, E.M., Lee, J.K., Lau, T.C., Songpatanasilp, T., Lee, K.B., Kim, K.J., Chen, J.F., Huang, K.E., Gau, Y.L., Chang, Y.F., Ebeling, P., Xia, W., Yu, W., Suzuki, A., Hew, F.L., Mercado-Asis, L.B., Chung, Y.S., Tsai, K.S., Lin, G.T., Yang, R.S., Wu, C.H. (2018) Consensus on best practice standards for Fracture Liaison Service in the Asia-Pacific region. *Archives of Osteoporosis*, 13(1): 59.
12. Majumdar, S.R., Beaupre, L.A., Harley, C.H., Hanley, D.A., Lier, D.A., Juby, A.G., Beaupre, L.A. (2007) Use of a case manager to improve osteoporosis treatment after hip fracture: results of a randomized controlled trial. *Archives of Internal Medicine*, 167(21): 2110-2115.
13. Majumdar, S.R., Johnson, J.A., Lier, D.A., Russell, A.S., Hanley, D.A., Blitz, S., Steiner, I.P., Maksymowych, W.P., Morrish, D.W., Holroyd, B.R., Rowe, B.H. (2007) Persistence, reproducibility, and cost-effectiveness of an intervention to improve the quality of osteoporosis care after a fracture of the wrist: results of a controlled trial. *Osteoporosis International*, 18(3): 261-270.
14. Wu, C.-H., Chen, C.-H., Chen, P.-H., Yang, J.-J., Chang, P.-C., Huang, T.-C., Bagga, S., Sharma, Y., Lin, R.-M., Chan, D.-C. (2018) Identifying characteristics of an effective fracture liaison service: systematic literature review. *Osteoporosis International*, 29(5): 1023-1047.
15. Royal College of Physicians, Falls and Fragility Fracture Audit Programme (2024) Fracture Liaison Service Database (FLS-DB) annual report 2024: rebuilding FLSs to meet local patient need. Royal College of Physicians, London.
16. Li, N., Hiligsmann, M., Boonen, A., van Oostwaard, M.M., de Bot, R.T.A.L., Wyers, C.E., Bours, S.P.G., van den Bergh, J.P. (2021) The impact of fracture liaison services on subsequent fractures and mortality: a systematic literature review and meta-analysis. *Osteoporosis International*, 32(8): 1517-1530.
17. Axelsson, K.F., Jacobsson, R., Lund, D., Lorentzon, M. (2016) Effectiveness of a minimal resource fracture liaison service. *Osteoporosis International*, 27(11): 3165-3175.
18. González-Quevedo, D., Bautista-Enrique, D., Pérez-del-Río, V., Moreno, D., Amaro-Domínguez, F., Bravo-Bardají, M., García-Villanueva, A., Tenorio, J.A. (2020) Fracture liaison service and mortality in elderly hip fracture patients: a prospective cohort study. *Osteoporosis International*, 31(1): 77-84.
19. Kim, M.S. et al. (2025) The impact of a fracture liaison service for patients with femoral fractures on subsequent fractures and mortality: focusing on systematic literature review and metaanalysis. *Archives of Osteoporosis*, 20(1): 24.
20. Wu, C.-H., Kao, I.-J., Hung, W.-C., Lin, S.-C., Liu, H.-C., Hsieh, M.-H., Bagga, S., Achra, M., Cheng, T.-T., Yang, R.-S. (2018) Economic impact and cost-effectiveness of fracture liaison services: a systematic review of the literature. *Osteoporosis International*, 29(6): 1227-1242.
21. McLellan, A.R., Wolowacz, S.E., Zimovetz, E.A., Beard, S.M., Lock, S., McCrink, L., Adekunle, F., Roberts, D. (2011) Fracture liaison services for the evaluation and management of patients with osteoporotic fracture: a cost-effectiveness evaluation based on data collected over 8 years of service provision. *Osteoporosis International*, 22(7): 2083-2098.
22. Naranjo, A., Prieto-Alhambra, D., Sánchez-Martín, J., Pérez-Mitru, A., Brosa, M. (2022) Cost-effectiveness analysis of fracture liaison services compared with standard of care in the secondary prevention of fragility fractures in Spain. *ClinicoEconomics and Outcomes Research*, 14: 249-264.
23. Xu, L., Zhao, T., Perry, L., Frost, S.A., Di Tanna, G.L., Wang, S.,

Chen, M., Kolt, G.S., Jan, S., Si, L. (2024) Return on investment of fracture liaison services: a systematic review and analysis. *Osteoporosis International*, 35(6): 951-969.

24. Mugnier, B., Daumas, A., Doddoli, S., Vellas, B., Rolland, Y., Sourdet, S. (2020) Adherence to fracture liaison service programs in patients over 70: the hidden part of the iceberg. *Osteoporosis International*, 31(4): 765-774.
25. Kanis, J.A., Johnell, O., Oden, A., Johansson, H., McCloskey, E. (2008) FRAX and the assessment of fracture probability in men and women from the UK. *Osteoporosis International*, 19(4): 385-397.
26. Ganda, K. (2021) Fracture liaison services: past, present and future. *Osteoporosis International*, 32(8): 1461-1464.