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Abstract

Summary
Mobile fracture prevention services, with DXA, significantly improved access to care for those at high risk of fracture living in rural areas. Introduction of mobile services facilitated access to fracture liaison services, and development of integrated of care pathways across community and secondary based care.

Introduction
The ageing population is growing faster in rural areas, yet most fracture prevention services are located in urban areas. As part of a wider study, evaluating introduction of mobile fracture prevention services, we focus on whether mobile services improve access to care for those at highest risk of fracture.

Methods
Services outcomes were assessed against the Royal Osteoporosis Society Clinical Standards for Fracture Liaison Services. This included standardised, age-specific referral rates, FRAX 10-year probability of major osteoporotic and hip fracture of referrals, pre and post introduction of the mobile service across two island and one rural mainland sites. This was compared to referrals from a similar rural mainland region with local access to a comprehensive service.

Results
Greatest impact occurred in areas with most limited service provision at baseline. Mean age of patients referred increased from 59-68 years (CI 6.8-10.1, $p<0.001$). Referral rates increased from 2.8 to 5.4 per 1000 population between 2011 and 2018, with a 5-fold rise in those ≥75 years (0.4 to 2.0 per 1000). Mean FRAX 10-year risk of major osteoporotic fracture increased from 12.7 to 17.7% (CI 3.2 – 5.7, $p<0.001$). Mean hip fracture risk probability increased from 3.0 to 5.7% (CI 2.0-3.4, $p<0.001$). However, referral rates from the mobile sites remained lower than the comparator site.

Conclusions
Mobile fracture prevention services, including DXA, greatly improved uptake amongst high-risk individuals. Mobile services facilitated development of integrated of care pathways, including fracture liaison services, across community and secondary based care.

Keywords

Osteoporosis, fracture liaison services, DXA scanning, mobile services, geographical access.

Introduction

Effective management of osteoporosis and associated morbidity requires a multi-disciplinary, system-wide approach (1). This includes identification of those at high risk of fracture, appropriate assessment, treatment and follow-up. Patient education and falls prevention are key elements of this. Service models such as comprehensive Fracture Liaison Services (FLS) have been shown to be a clinically and cost effective means of identifying and managing individuals at high risk of fragility fracture (2). However, despite a wealth of best practice guidelines, significant care gaps remain (3, 4), especially for the elderly where the importance and impact of treatment is highest (5). With an ageing population, the number of osteoporotic fractures are expected to rise, yet the provision of and access to FLS internationally remains patchy (6-8).

Ensuring equitable access to fracture prevention services for an increasingly elderly population is challenging. Most services are located in urban areas, yet the ageing, multi-morbid population is increasing faster in rural areas (9-12). Rural location plays an important role in determining ease of access to and provision of health services (13). Poor transport infrastructure and the car dependent nature of travel in many rural areas means there is a rising rate of mobility-related exclusion from health care, especially in the elderly (10). This can compound and amplify the negative health effects of other inequalities such as physical and social isolation, poor housing and low income which impact disproportionately on rural communities (14) and is reflected in overall lower levels of health service use (15).

Mobile DXA services, comprising of a whole body DXA scanner housed in a specially adapted van, have previously been introduced to address geographical inequalities in access to DXA for those living in rural communities. In the United States, the Geisinger Health System Osteoporosis Program (16) introduced a mobile DXA scanner (17). Patients scanned on the mobile scanner were older and had lower T-scores. Although more costly and less efficient than a static DXA unit, the mobile units were found to be financially self-sustaining due to the volume of patients scanned (17). In Australia, a mobile DXA service was introduced as part of a fracture liaison service (FLS) (18). In 2008, four mobile DXA scanning services were piloted to address inequalities in assess to DXA services in rural England, UK. Limited evaluation focused on number of DXA scans performed (19) and only one service was subsequently embedded into routine clinical practice.

Study aims

It remains unclear if mobile fracture prevention services with DXA, can support delivery of a comprehensive fracture prevention service and improve access to older individuals at highest risk of fracture. Scotland, with a geographically diverse and ageing population spanning urban, rural and remote islands provided an ideal pilot setting to explore some key questions about patient access to services and preferences; service uptake and referral patterns. Equally, it provided an opportunity to compare the adoption of mobile services across diverse geographical and organisational settings.

We designed and conducted a purposive three-year prospective study to evaluate the introduction of a mobile fracture prevention service, including DXA, alongside existing static services, across three contrasting rural and remote regions in Northern Scotland (two islands and one mainland setting). We examined implementation of the new service using survey and interviews with a diverse group of stakeholders and explored the acceptability of the service. These findings are reported elsewhere (20). In this paper, we focus primarily on whether introduction of a mobile service improved access to services for those at increased risk of fracture; changes in referral rates and fracture risk of individuals referred into the service. Service outcomes were assessed against the Royal Osteoporosis Society Clinical Standards for Fracture Liaison Services (FLS) which were introduced in 2019 (21).

Methods

Service setting

The Grampian Osteoporosis Service (GOS), based in Aberdeen, Northern Scotland, provides National Health Service (NHS) fracture prevention services to three regional health boards (Grampian, including Moray, and the islands of Shetland and Orkney). This spans a population of 0.6 million spread over 3000 square miles of urban, rural mainland and remote island communities, see Figure 1. In addition to the main service in Aberdeen, a satellite service of GOS serves an older, rural area with a population of around 90,000 (Moray). The multi-disciplinary team (comprising osteoporosis consultants, specialist radiographers and osteoporosis specialist nurse) is the single care provider of all osteoporosis services in the region.

Figure 1.

Direct access DXA services were available to local primary and secondary care practitioners for patients identified at high risk of fracture. Local referral criteria for bone density scanning was based on assessment of clinical risk factors and use of Fracture Risk Assessment Tools such as FRAX, with individuals with a FRAX or QFracture score > 10% recommended for assessment with DXA This was formalised in 2015 with the publication of SIGN 142 (22). Given the large geographical area covered by the service, including multiple community based hospitals, the service has a well-established radiographer-led Fracture Liaison Service (FLS) that systematically identified patients over the age of 50 years with fracture from x-ray reports. Prior to introduction of the mobile service, FLS was only available on the mainland (Grampian and Moray). On the islands there was no means of subsequently assessing patients locally and travel to the mainland was costly and time-consuming.

Implementation of mobile fracture prevention service

Ensuring equitable access to fracture prevention services for an increasing ageing population presented significant challenges to the service. Elderly patients living in rural (represented by Marr in this report) and remote areas, especially the islands, reported long, arduous and complex journeys to access the service in Aberdeen. A mobile fracture prevention service was created to address these unacceptable disparities in access to care, and piloted in two island communities (Shetland and Orkney) and one rural mainland site in Grampian (Marr).

The mobile service was introduced to the Shetland Isles and Marr in September 2014, and Orkney in February 2016. Hosted by local community hospitals, the mobile service made two visits per year to Shetland, three visits per year to Orkney and four visits per year to Marr. Following this, the FLS operating in Grampian was extended to the islands. Regional primary care and patient education events supported introduction of the mobile service.

Evaluation of mobile fracture prevention service

The overall study period is seven years, examining the period before, during and after introduction of the mobile service. Evaluation of the new service comprised a number of distinct stages and approaches; patient surveys before and after introduction of the mobile service; analysis of routinely collected clinical and service data on referrals, including assessment of individual fracture risk; cost data before and after the new service was in place. As part of the wider evaluation, we collected detailed interview data from a wide range of stakeholders involved in implementing the new service. These are reported elsewhere (20).

There are no data to our knowledge to indicate what the appropriate referral rates should be for a rural, and increasingly elderly population. Moray was chosen as the comparator region because it was similar to our 'target population' (predominately rural with a similar age demographic (23)), but with local access to comprehensive fracture prevention services, including FLS. Moray therefore provided the best available comparative estimate of the expected target referral rates for assessment in our target population.

Routinely collected clinical data

We extracted data on DXA scans performed from 1st April to 31st March each year from 2011 to 2018 from the GE Lunar Prodigy DXA scanning database. This was cross-referenced this with regional NHS Health Intelligence datasets, which captures all outpatient DXA activity and patient demographics.

Patients from the mobile pilot sites referred to the fracture prevention service two years pre and post introduction of the mobile service were characterised using data obtained from bone health questionnaires and the DXA scanning service database; age, gender, postcode of residence, body mass index, FRAX risk factors, and femoral neck T-score. FRAX 10-year risk of major osteoporotic and hip fracture probability were calculated (including BMD). Similar data was collected on all patients referred from Moray over a six-month period in 2016/17 (May-July and Nov-Jan to account for seasonal variation in referrals).

Patient survey

All patients attending the fracture prevention service in Aberdeen for assessment over a one month period prior to introduction of the mobile service, and all patients attending the mobile service at each pilot site during its first year of operation were invited to participate in a short paper-based survey. This gathered information on journey (e.g. method transport, travel time), factors influencing decision to access to services, and preferences for use of mobile versus static services.

Statistical analysis

Age specific DXA referral rates (0-49, 50-64, 65-74 and ≥ 75 years) per 1000 population, standardised to the 2011 Scotland population, were calculated across regions (determined by postcode of residence) pre and post introduction of the mobile fracture prevention service. Population denominators for each region (Aberdeen City, Aberdeenshire, Moray and the islands), per age group from 2011 to 2017 were obtained from mid-year population estimates (24), with the exception of Marr which was not available. Here, the population denominator for Marr was calculated using annual general practice list sizes for all practices in the region. Patient demographics, FRAX risk factors and survey data were analysed using descriptive statistics in STATA version 14 (StataCorp, College Station, Texas, 2015). No significant differences were found between individual islands therefore data from both islands were combined and presented collectively. Results are presented as mean [standard deviation] and number (%) FRAX risk factors. Fracture probability scores were calculated inclusive of femoral neck T-scores where available in those > 40 years. Independent *t*-tests were calculated, with significance $\alpha < 0.05$.

Results

28,349 patients were referred to the service between 2011 and 2018. 1679 DXA scans were undertaken across all the mobile pilot sites between September 2014 and April 2018.

Clinical Standards for FLS

The mobile service was assessed against the six domains of the Royal Osteoporosis Society Clinical Standards for FLS, published in 2019 (21), and the findings summarised in Table 1. Further details on specific domains are discussed below.

Insert Table 1

Investigate

All patients attending the service (central or mobile) underwent a comprehensive assessment of bone health, including; bone health questionnaire, falls risk assessment and DXA scanning (including vertebral fracture assessment). Prior to the introduction of the mobile service, there were significant differences in the rates of individuals attending for assessment (referral rates) between regions with very limited access to osteoporosis services (islands), access to core services (Marr) and those with local access to comprehensive fracture prevention services (Moray). Differences in referral rates were most marked in older age groups.

Figures 2 – 4 illustrate the age specific referral rates (50-64, 65-74 and ≥75 years) per 1000 population, respectively, across the islands, Marr and Moray between 2011 and 2018. Overall referral rates for each region is shown in supplementary material.

Insert Figure 2 - 4

In 2011, referral rates for those aged less than 50 years were appropriately low, but there were no clinically significant differences between the islands, Marr and Moray (0.8, 1.0 and 1.1 per 1000 respectively) (see supplementary material).

In the islands, referral rates for those aged 50-64 years were 2.8-fold lower than Moray (0.9 compared to 2.6 per 1000). Referrals rates for those aged 65-74 years were 2.5-fold lower (0.8 compared to 2.0 per 1000) and in those aged 75 and over, 4-fold lower (0.4 compared to 1.7 per 1000).

In Marr, referral rates were slightly lower compared to Moray for those aged 50-64 years (2.4 compared to 2.6 per 1000), with greater differences in referral rates for those aged 65-74 years (1.5 compared to 2.0 per 1000) and 75 years and over (1.0 compared to 1.7 per 1000).

This was reflected in a lower mean age of referrals; 59 years [SD 14] in the islands, 63 years [SD 13] in Marr compared to 64 years [SD 14] in Moray.

Change in referral patterns across regions following introduction of mobile services

Referral rates increased across all regions, most marked in the islands where rates increased from 2.8 to 5.4 per 1000. There was a smaller increase in referral rates in Marr; 5.9 to 6.8 per 1000. However, they remained lower in the mobile sites compared to Moray, where referral rates increased from 7.4 to 9.1 per 1000.

However, there were differing patterns in age-specific referral rates over time and between regions following introduction of the mobile service, see Figures 2 - 4. Across all regions, referrals from those < 50 years fell, with a significant decrease in the islands (0.8 to 0.4 per 1000) and Moray (1.1 to 0.5 per 1000), with a smaller decrease in Marr (1.0 to 0.8 per 1000), see supplementary material.

In the islands, the greatest increase in referral rates was seen in older age; 50-64 years rates increased from 0.9 to 1.5 per 1000; 65-74 years rates increased from 0.8 to 1.5 per 1000; and in those >= 75 years there was a 5-fold increase in referral rates, from 0.4 to 2.0 per 1000. In 2013 prior to introduction of the mobile service, and following a series of primary care focused education sessions on osteoporosis, there was an early increase in referrals from those aged 50-74 years. 2016/17 saw a further significant spike in referral rates in those > 65 years that subsequently decreased.

In Marr, there was no change in referral rates for those aged 50-64 and 65-74 years. However, in those aged > 75 years, referral rates increased more than 2-fold from 1.0 to 2.2 per 1000.

In Moray, referral rates increased continued to rise, especially in older age groups; 50-64 years rates increased from 2.6 to 3.0 per 1000; 65-74 years rates increased from 2.0 to 2.8 per 1000; and in those >= 75 years there was a 2-fold increase in referral rates from 1.7 to 2.8 per 1000.

Introduction of new Scottish Intercollegiate Guidelines Network (SIGN) guidelines for the management of osteoporosis in 2015 shifted emphasis toward scanning fewer younger patients and focused attention on those older patient at higher fracture risk (22). This may have contributed to the overall reduction in referrals from those less than 50 years, and rise in referrals in older age groups across all regions.

Appropriate targeting of interventions to those at highest risk of fracture

It was important to determine whether the mobile service was appropriately targeting those at highest risk of fracture. Table 2 illustrates the demographics, FRAX risk factors, FRAX 10-year major osteoporotic and hip fracture probability (calculated with BMD) of those referred into the service two years before and two years after introduction of mobile services to the Islands and Marr. This was compared to those referred to the service in Moray over a 6-month period in 2016/17.

Insert Table 2

Islands: More patients at higher risk of major osteoporotic and hip fracture were referred following introduction of the mobile service. The mean age of patients referred to the service increased from 59 to 68 years, (CI 6.8 – 10.1, p<0.001) and was comparable to those from the existing rural service in Moray. The mean FRAX 10-year risk of major osteoporotic fracture increased from 12.7 to 17.7% (CI 3.2 – 5.7, p<0.001). Mean hip fracture probability increased from 3.0 to 5.7% (CI 2.0-3.4, p<0.001). The percentage of those referred with a FRAX probability of major osteoporotic fracture ≥ 15% increased from 32% to 53% and was comparable with Moray. Those with a FRAX probability of hip fracture 5 - 9.9% increased from 14 to 26%, and those with a FRAX probability of hip fracture ≥ 10% increased from 6 to 17%, and was comparable with Moray (see also supplementary material).

Marr: the mean age of patients increased from 65 to 67 years (CI 0.0 – 4.0, p = 0.05) and was comparable to Moray. However, there was no overall clinically significant change in mean FRAX 10-year risk of major osteoporotic and hip fracture following introduction of the mobile service. The percentage of those referred with a 10-year risk of major osteoporotic fracture > 15% increased

from 42 to 46%. Those with a 10-year risk of hip fracture risk 5 - 9.9% increased from 17 to 20%, with a slight decrease in percentage of referrals with hip fracture risk >=10% (12.8% to 11.8%). The percentage of referrals at highest risk of fracture remained slightly lower than Moray (see also supplementary material).

Intervene

Prior to introduction of the mobile service there was effectively no access to any form of assessment. Whilst introduction of the mobile service to rural and remote regions significantly improved this, access to fracture prevention services remained limited, especially on the islands. Recognising that this contributes to a delay between fracture and treatment initiation, local guidelines were introduced to support early initiation of treatment in high risk individuals whilst awaiting formal assessment

Between March 2017 and March 2018, 376 patients were scanned on the islands, in whom osteoporosis treatment was recommended in 45% (n=169). Four months following initial assessment and recommendation to the general practitioner to commence treatment, letters were routinely sent to patients to promote concordance, along with an invite to contact the Grampian Osteoporosis Advice Line if they were experiencing any problems. Of the 155 patients alive at one year following initial assessment, 80% (n=124) were still prescribed treatment by their general practitioner (as determined by an active prescription on the electronic primary care summary). Of the 29 not on treatment, reasons were given in 4 (e.g. dementia). In one year across the three mobile sites, there were 171 new diagnoses of osteoporosis, 15% (n=26) of whom were identified as being at high risk of falls. Of those, 77% (n=20) had ≥1 prior fracture. These patients were referred directly to the local falls team.

Integrate

The mobile service facilitated new pathways of integrated care across community and secondary care services; raising awareness of osteoporosis, and fostering a sense of shared ownership to identify service gaps and create solutions sensitive to local geography, staffing and patient preferences, see Table 1.

However, integration within the wider healthcare system met with a number of challenges. Support for mobile services varied across sites as local priorities shifted in response to wider political pressures and resource constraints. For example, in 2012 the Scottish Government transferred central funding for subsidised travel from rural areas to access healthcare, to local health boards. This was intended to incentivise “repatriation” of services to the islands by enabling health boards to keep any cost savings made, and was a key driver for mobile service development. However, concurrent introduction of national waiting time targets for other services resulted in more ‘off island’ journeys as existing services did not have the capacity to meet demand within the designated time frame. This negated potential cost-savings created by the mobile service, and one island health board subsequently decided to fund only two visits per year of the mobile service. This limited the capacity of the mobile service to meet increased demand, which in turn negatively impacted on the number of people seen for assessment. Concerns were also raised about increased prescribing costs, increased demand on services, for example, falls teams and the ability of services to deliver this.

Quality

The service was engaged in a programme of continuous improvement. Local data indicated that the FLS picked up 99% of hip fractures identified in the National Hip Fracture Audit 2018 (25). Data gathered on patient experiences of care was used to inform service improvements. Pre-introduction of mobile service, 200 patients attending the service in Aberdeen in July 2014 were surveyed (response rate 99%, n=197). Travel distance and time, fear of delays, car parking, poor availability and accessibility of public transport, adverse weather as well as high personal travel costs influenced decisions to access osteoporosis services. For many rural patients, physically accessing urban-based services was especially challenging following a fracture. 45% of rural dwellers relied on family and friends to access urban-based services, compared to only 23% of patients of urban dwellers. 90% of rural mainland and 99% of islands patients stated they would prefer to be scanned locally.

Post-introduction of mobile service, 494 patients attending in the mobile service at each pilot site in the first year following its introduction were surveyed (response rate 75%, n=370). The mobile service significantly reduced journey time and complexity for many patients, and delivered improved quality of care at less cost, see Table 1. However, 25% of referrals from Marr requested assessment in Aberdeen; these patients were younger (mean age 65 years) and tended to live and work closer to Aberdeen.

Discussion

Introduction of a mobile fracture prevention service increased referral rates from regions with previously poor access to osteoporosis services. There was a significant increase in older individuals at high risk of future fracture, as determined by FRAX, referred into the new mobile service. The mobile service provided access to multi-disciplinary fracture prevention care, including FLS, at no additional cost.

This study collected longitudinal routine clinical data to support the contemporaneous introduction and evaluation of a new service delivery model, while informing ongoing service development and sustainability. It was distinctive in having the opportunity to collect before and after data from both patients and clinical data sets. However, we acknowledge some limitations. We do not have fracture data to demonstrate impact of service change on fracture reduction within the current study time frame, however, the early goal was to bring equity of access to fracture prevention care.
Whilst the observational nature of the evaluation meant it was not possible to control for external factors, such as policy changes at local and national level, it did provide a unique opportunity to examine their impact on service development over time.

In keeping with other studies, we have shown that introduction of DXA services to regions with previously limited access increased uptake (26-29). Whilst recognising screening populations are different, mobile screening units have similarly been associated with increased uptake in rural communities in breast cancer screening (30-32) and diabetic retinal screening (33). The limited evidence regarding the implementation of other mobile screening services similarly demonstrates that developing and utilising community links (34-37) are important in successfully implementing and sustaining mobile healthcare services.

Whilst other studies have similarly highlighted the importance of perceived travel burden on the decisions of those living in rural communities to access care (38), our findings also suggest that factors other than geographical accessibility are important. Despite improved access to services, referral rates remained lower in the pilot sites compared to Moray. As the single service provider for

the area, individuals were not being assessed elsewhere. As well as physical impairment and increasing age, living alone and low perceived risk of fracture have been shown to influence non-participation in osteoporosis screening studies (39) and anti-osteoporotic medication uptake (40). Similarly, evidence from screening in other chronic diseases such as diabetic retinal screening highlight the challenges of targeting high-risk groups (33). For those living in remote rural areas, a culture of self-reliance has also been shown to be important in shaping access to, and use of, healthcare services (38).

This study has a number of implications for healthcare policy and practice. While the ROS Clinical Standards for FLS provided a robust framework to evaluate the new service against, both local and national policy played a significant role in shaping service development and outcomes. Introduction of the mobile service resulted in a significant reduction of costs per person scanned, yet the value local organisations attached to developing osteoporosis services varied depending on how well such services matched local strategic priorities. Addressing unmet clinical need was valued by health service managers, but they also expressed concern about increased prescribing costs and local demand for services. If such services can be shown to reduce fractures then the projected cost savings can be reconciled against managerial pressure for immediate cost savings. Our study has gone part of the way along the road to that ultimate goal. We have also highlighted the importance of a coordinated multi-level approach at policy, organisation and individual level to improve fracture prevention care in a healthcare landscape characterised by increasingly fragmented care across multiple care providers. Flexible and cohesive policies are needed to enable healthcare organisations to regionally determine their services to best suit the needs of local communities, promote shared learning and support local collaborative working.

Prior to implementing local service change, it is important to identify service gaps and unmet need in the context of local geography, staffing and patient preferences. As healthcare resources are squeezed, it is essential that service change is shown to be both effective and provide value for money. Timely and comprehensive evaluation of service change beyond purely quantitative metrics is important to capture the wider benefit of services change (41). Implementation of the mobile service also revealed a number of practical learning points which we have described elsewhere (20); including technical and logistical considerations, the challenges faced by staff in delivering care remotely, and the importance of maintaining staff 'buy in,' and 'selling' the service to a diverse group of stakeholders.

Recent attention has focused on the effectiveness of screening strategies for fracture prevention (42, 43). This includes equitable access to comprehensive fracture prevention services targeted to those at highest risk of fracture, and provision of integrated fracture and falls prevention strategies (44). We have demonstrated that a mobile fracture prevention service, including DXA, can effectively broaden access to a comprehensive fracture prevention service for older individuals at higher risk of fracture. Future work should evaluate the impact of upscaling mobile services to other geographical areas and examine the longer-term impact of service change on service uptake, prescribing patterns of osteoporosis medication and fracture incidence.

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Table 1. Summary of service changes, assessed against ROS Clinical Standards for Fracture Liaison Services.

Domain	**Changes following introduction of mobile services**
IDENTIFY: *People aged 50 years and over with a fragility fracture are systematically identified*	Islands: introduction of FLS, with 20% increase in the number of patients with prior fracture assessed Marr: 15% increase in the number of patients with prior fracture assessed
INVESTIGATE: *Investigations to assess risks of fragility fractures and falls and possible underlying secondary causes for osteoporosis are offered to people identified by the FLS*	Greatest impact occurred in areas with most limited service provision at baseline Mean age of patients referred increased, with greatest increase in referral rates seen in those ≥ 75 years More patients at higher risk of major osteoporotic and hip fracture referred
INFORM: *Information and support are offered to people coming into contact with the FLS, and, where appropriate, their carers*	Tangible, visible focal point for the cross-boundary service Facilitated engagement with broad range of health and social care professionals, public and community-based services Up-skilling of island physiotherapists to deliver local 'drop in' education sessions for patients Access to local advice and peer support for patients
INTERVENE: *Interventions to reduce the risk of fragility fractures are offered to people as required*	Clinical pathways introduced to initiate early treatment in high risk individuals following fracture and support concordance
INTEGRATE: *The FLS will integrate with the wider healthcare system to facilitate an inclusive patient pathway, ensuring case finding, onward referrals and long-term management of osteoporosis*	Development of locally tailored initiatives e.g. enhancement of community-based peripatetic services and 'Can we catch you before you fall' (collaboration with island occupational therapy teams, offering a Multifactorial Community Falls Risk Screen to all high risk individuals) Direct referral to falls services for newly diagnosed individuals at high risk of falls
QUALITY: *The FLS demonstrates clinical accountability, effective governance, professional development and ongoing service improvement*	Mean journey times for patients attending Island and Marr pilot sites reduced from *13 hours to 47 minutes* and *61* to *23 minutes* respectively Missed appointments at mobile pilot sites lower than urban service (6% vs 9%) Islands costs: £124 per person (based on scanning 70-80 individuals per visit, including staff costs, travel time and expenses, maintenance, depreciation and capital replacement of equipment) compared to £390-£490 per person travel costs to Aberdeen Mainland (rural and urban service): overall cost neutral

Table 2. Characteristics and FRAX probability of major osteoporotic and hip fracture pre- and post-introduction of mobile fracture prevention service to islands and Marr.

	Island Referrals Pre-mobile (n=342)	**Islands Referrals Post mobile[a] (n=592)**	**Marr Referrals Pre-mobile (n=305)**	**Marr Referrals Post mobile[a] (n=339)**	**Elgin Referrals [b] (n=529)**
Age (years) Mean (CI)	59 (58 – 61)	68 * (67 – 69)	65 (63 – 66)	67 ¥ (65 – 68)	67 (66 – 68)
% Female (n)	80% (275)	82% (488)	88% (268)	76% (259)	78% (415)
Previous fracture	44% (152)	64% (380)	56% (171)	71% (240)	76% (404)
Parent hip fracture	17% (59)	8% (49)	17% (52)	15% (50)	17% (92)
Current smoker	11% (38)	13% (77)	6% (18)	9% (39)	13% (70)
Alcohol > 3units/day	5% (18)	3% (20)	2% (6)	7% (23)	7% (37)
Glucocorticoid use	30% (101)	35% (205)	25% (77)	19% (64)	30% (158)
Rheumatoid arthritis	9% (32)	6% (36)	10% (29)	5% (18)	5% (28)
Secondary causes of osteoporosis	46% (158)	25% (150)	42% (129)	31% (106)	33% (173)
FN T-score Mean (CI)	-1.3 (-1.2 - -1.5) (n=326)	-1.7 * (-1.6 - -1.8) (n=562)	-1.5 (-1.4 - -1.6) (n=301)	-1.6 (-1.5 - -1.7) (n=329)	-1.7 (-1.6 - -1.8) (n=519)
FRAX 10-year major osteoporosis fracture probability (%) Mean (CI)	12.7 (11.7 – 13.6) (n=311)	17.1 * (16.4 – 17.9) (n=551)	15.5 (14.3 – 16.8) (n=285)	15.9 (14.9 – 17.0) (n=318)	18.8 § (17.8 – 19.8) (n=505)
FRAX 10-year hip fracture probability (%) Mean (CI)	3.0 (2.6 – 3.5) (n=311)	5.7 * (5.2 – 6.2) (n=551)	5.3 (4.4 – 6.2) (n=285)	5.1 (4.4 – 5.8) (n=318)	6.6 § (5.8 – 7.3) (n=505)

[a] Independent *t*-test comparing means pre and post introduction of mobile service (*p<0.001, ¥p= 0.05). [b] Independent *t*-test comparing differences between Moray and mobile pilot sites post-introduction of mobile service (§ $p < 0.05$)

Figure 1. Catchment area Grampian Osteoporosis Service

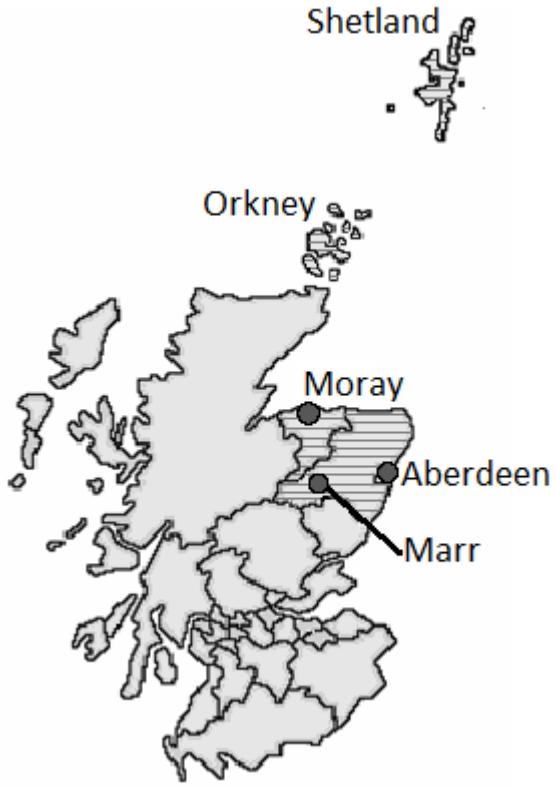


Figure 2 Referral rates (50-64 years) per 1000 population across regions from 2011-2018, adjusted to Scotland population demographics. * Discussion with primary care and osteoporosis education sessions. ** Mobile services introduced Shetland and Marr 2014, Orkney 2016.

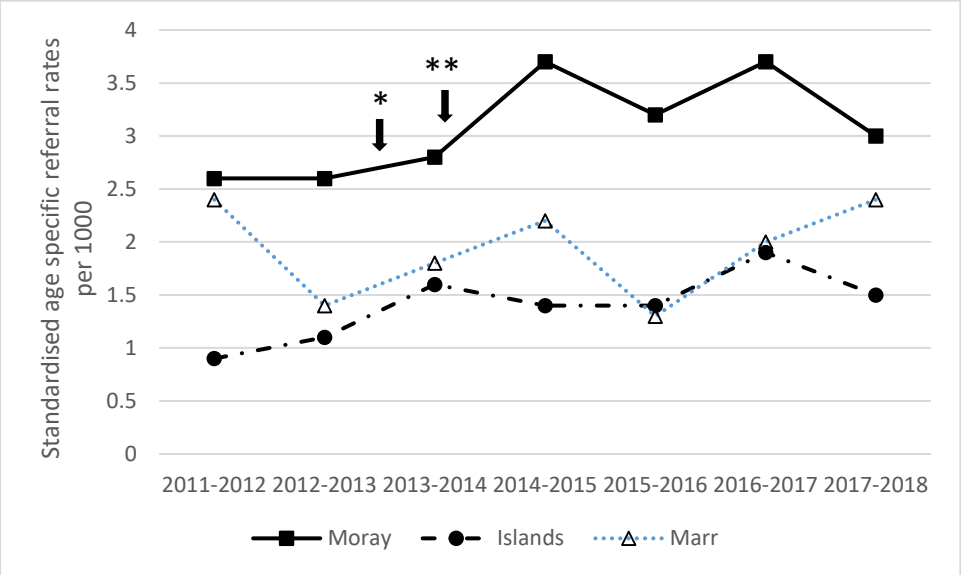


Figure 3 Referral rates (65-74 years) per 1000 population across regions from 2011-2018, adjusted to Scotland population demographics. * Discussion with primary care and osteoporosis education sessions. ** Mobile services introduced Shetland and Marr 2014, Orkney 2016.

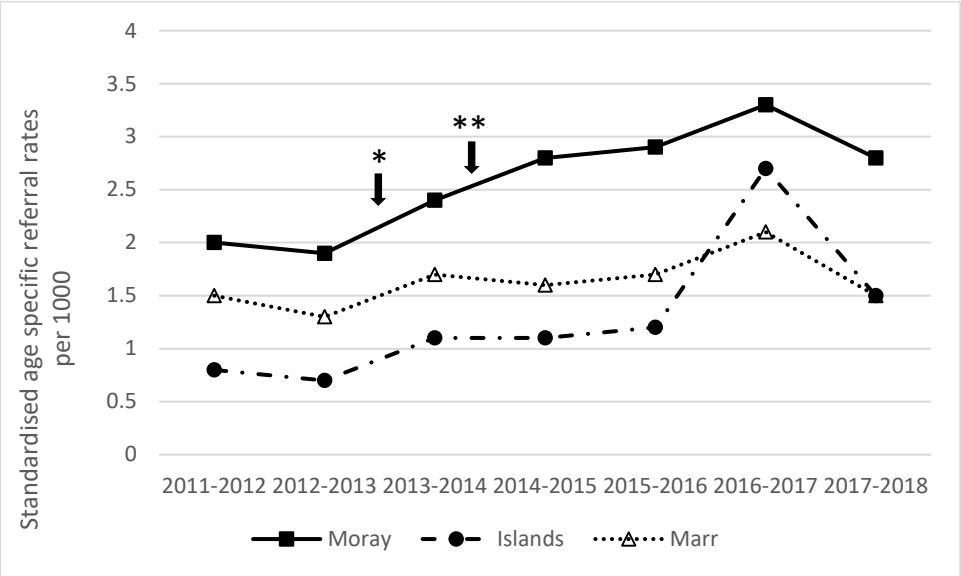
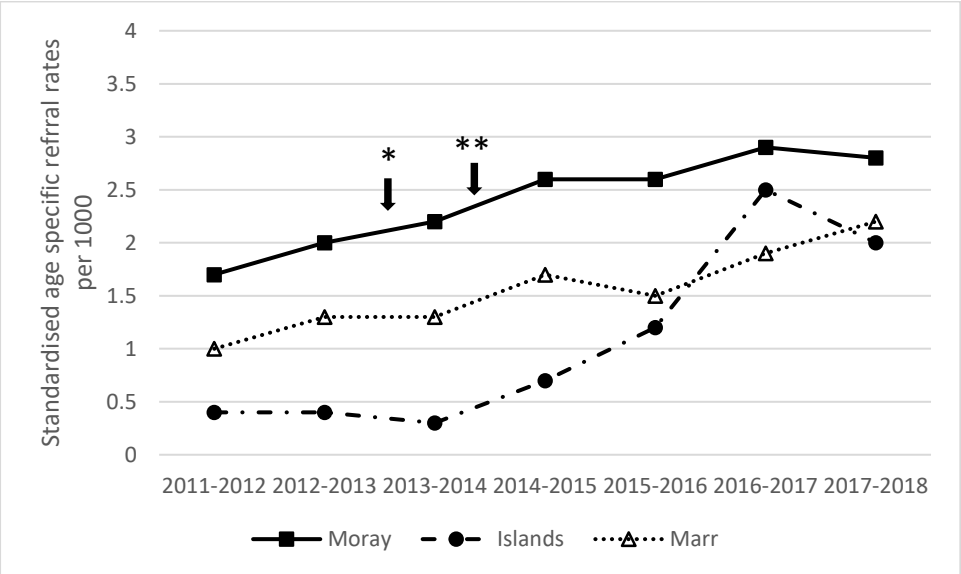


Figure 4 Referral rates (≥75 years) per 1000 population across regions from 2011-2018, adjusted to Scotland population demographics. * Discussion with primary care and osteoporosis education sessions. ** Mobile services introduced Shetland and Marr 2014, Orkney 2016.



Supplementary material

Figure 1 Referral rates (all ages) per 1000 population across regions from 2011-2018, adjusted to Scotland population demographics. * Discussion with primary care and osteoporosis education sessions. ** Mobile services introduced Shetland and Marr 2014, Orkney 2016.

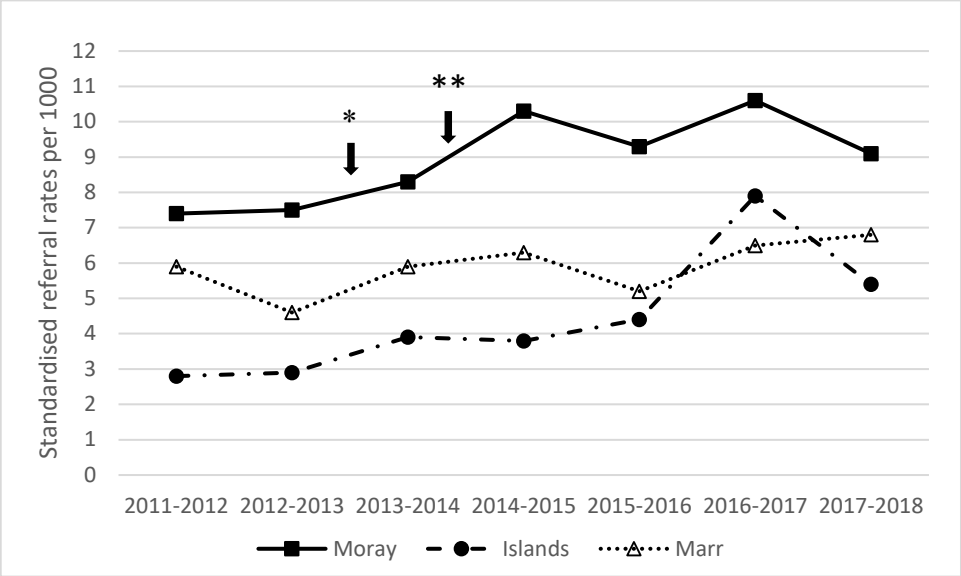


Figure 2 Referral rates (< 50 years) per 1000 population across regions from 2011-2018, adjusted to Scotland population demographics. * Discussion with primary care and osteoporosis education sessions. ** Mobile services introduced Shetland and Marr 2014, Orkney 2016.

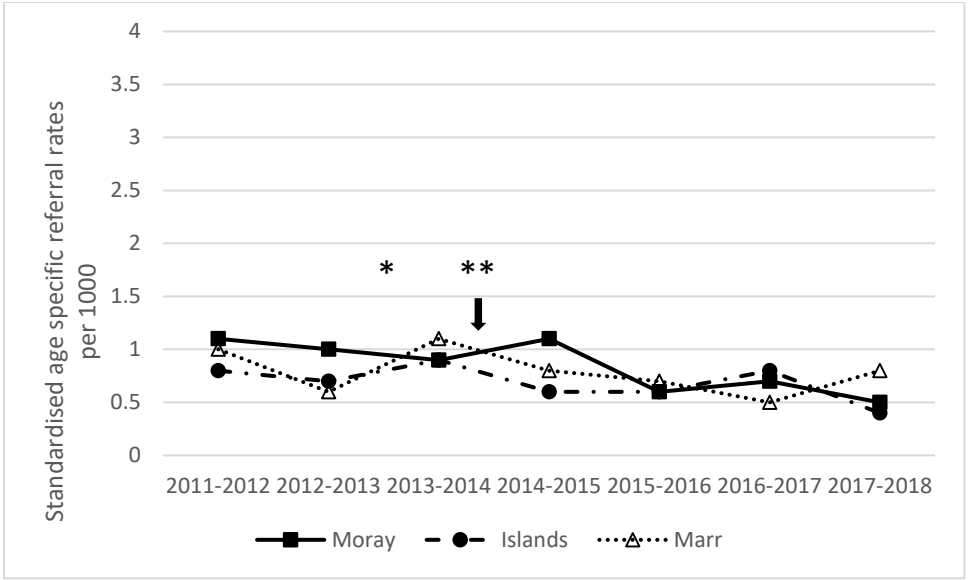


Figure 3 Islands referrals pre and post-introduction of mobile service (a) FRAX risk probability of major osteoporotic and (b) FRAX risk probability hip fracture

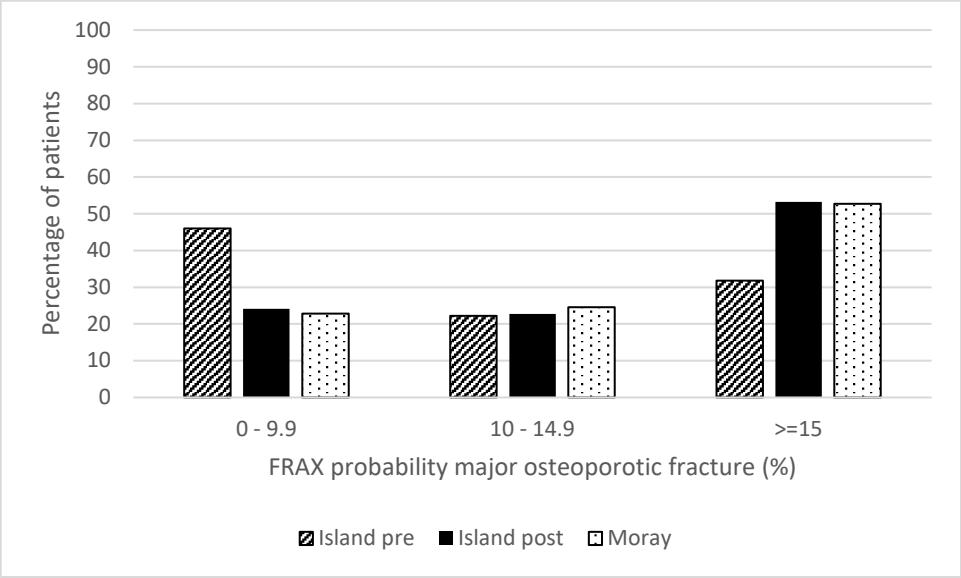


Figure 3 a.

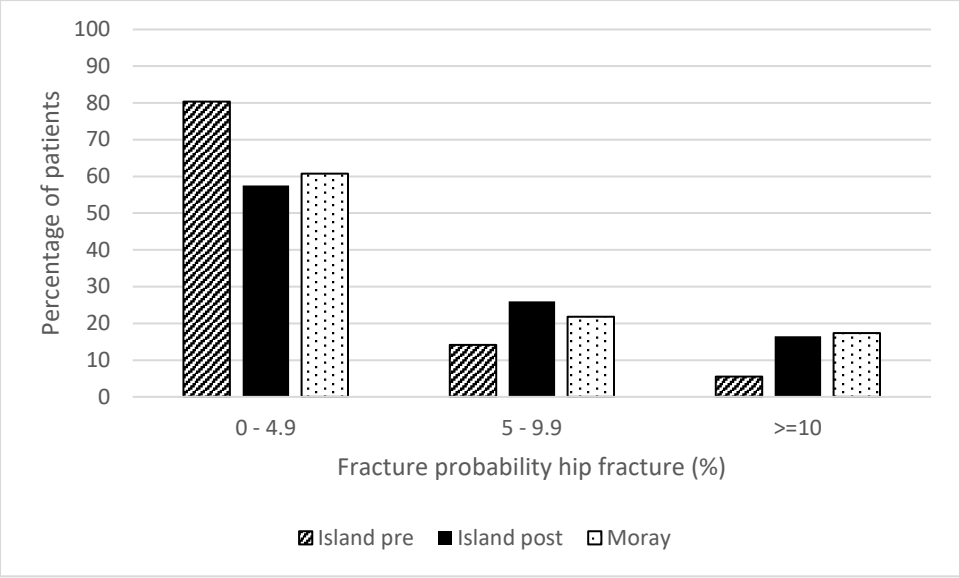


Figure 3 b.

Figure 4 Marr referrals region pre- and post-introduction of mobile service (a) FRAX risk probability major osteoporotic and (b) FRAX risk probability hip fracture

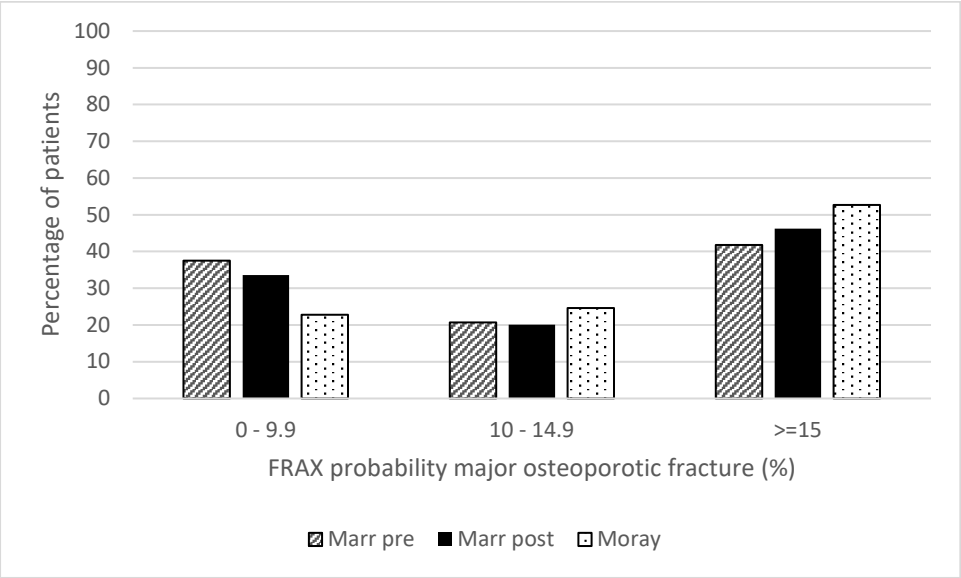


Figure 4 a.

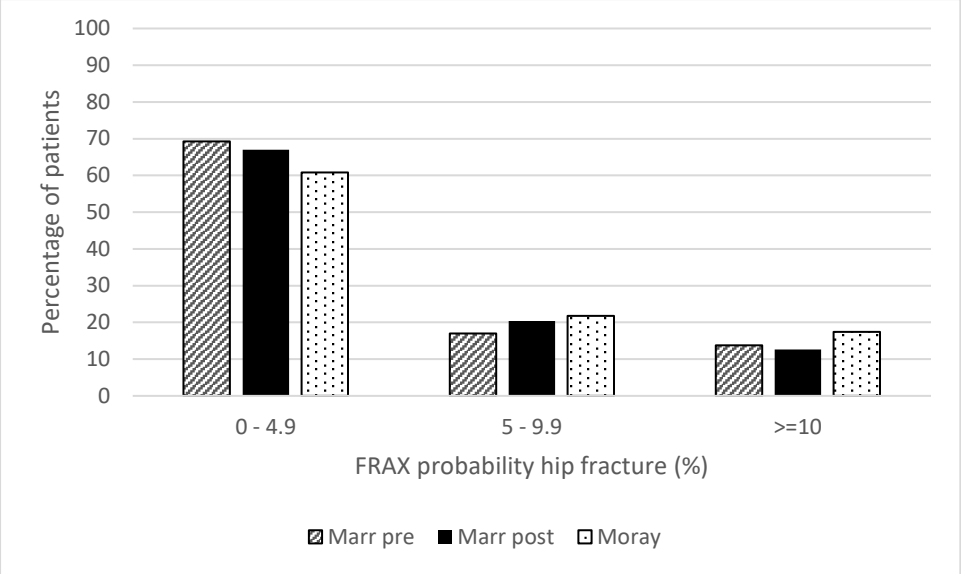


Figure 4 b.