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Covid-19 given opportunity to use ultrasound in the plaster room to continue secondary fracture prevention care: A retrospective Fracture Liaison Service study

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ABSTRACT

Introduction: Fracture Liaison Service (FLS) managed secondary fracture prevention services have been hampered during the COVID-19 pandemic. A challenging opportunity is to use pulse-echo ultrasound (P-EU) in the plaster room. The study had two objectives: can P-EU help our decision to justly avoid DXA/VFA scans in plaster treated women (50–70 years) after fracture and whether its use can encourage or nudge all plaster treated patients (>50 years) who need DXA/VFA scans.

Patients and methods: 1307 patients (cohort: pre-COVID-19) and 1056 patients (cohort: peri-COVID-19), each of them $\geq$ 50 years after recent fracture, were studied. Only in women aged 50–70 years, we used a P-EU decision threshold (DI) >= 0.896 g/cm^2 to rule out further analysis by means of DXA/VFA. All other plaster patients received P-EU as part of patient information. Peri-Covid-19, all performed DXA/VFA scans were counted until three months post-study closure. By then each patient still waiting for a DXA/VFA had received a scan.

Results: Peri-COVID-19, 69 out of 191 plaster-treated women aged 50–70 years were ruled out (36%), for plaster and not in-plaster treated women aged 50–70 years, it was 27%. Comparing all peri-to pre-COVID-19 plaster-treated women and men, a significant P-EU nudging effect was found (difference in proportions: 8.8%) P = .001.

Conclusion: The combination of patient information and P-EU in the plaster room is effective to reduce DXA/VFA scans and allow extra patients to undergo DXA/VFA. After all, more than a quarter of 50–70 years old women in plaster did not need to be scanned.

1. Introduction

The number of fractures in patients with osteoporosis is increasing worldwide (Eisman et al., 2012; Lems et al., 2017; Dreinhöfer et al., 2018; Conley et al., 2020). A substantial excess of the disease burden is the result of subsequent fractures, and in this perspective the ‘imminent fracture risk’ after the incident fracture (defined as the increased risk of subsequent fractures during the first two years after the index fracture) is particularly important (van Geel et al., 2009; Balasubramanian et al., 2019; Banefelt et al., 2019; Leonard et al., 2008). Healthcare providers must therefore remain alert to continue patient care in the prevention of new fractures.

The most practical model of secondary fracture prevention care is the Fracture Liaison Service (FLS) (McLellan et al., 2003). It is a model of care promoted by leading international scientific communities and by the International Osteoporosis Foundation (IOF) (Åkesson et al., 2013). But even with a wide international network of FLSs, health professionals still face a huge challenge in closing the gap between all patients with an osteoporotic fracture and those who actually receive active treatment to prevent new fractures (Lems et al., 2017; Dreinhöfer et al., 2018; Åkesson et al., 2013). We identified lack of structural and well-organized patient information being one of the most critical underlying problems (van den Berg et al., 2019; Raybould et al., 2018). Better patient information with a focus on the intrinsic neglect of skeletal health is critical to perform better (van den Berg et al., 2019; Raybould et al., 2018; Grover et al., 2014; Giangregorio et al., 2010) i.e.,

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you gain more DXA/VFA scans and a higher FLS attendance (van den Berg et al., 2019). Patient information must be available shortly after the fracture such as during fracture treatment in the plaster room. By then, the use of simple equipment to estimate the risk of a subsequent fracture will be very easy to plan (van den Berg et al., 2019).

In previous Finnish studies on P-EU, a significant correlation was found between a proposed threshold (Density Index (DI)) and BMD at the femoral neck. The optimal DI to rule out osteoporosis at the hip was $\geq$ 0.844 g/cm^2 (Karjalainen et al., 2012; Eneh et al., 2016). In a first FLS pilot study based on the Finnish experience but among women after fracture aged 50–70 years, P-EU technology showed to be efficient and useful to exclude those women not in need of a DXA/VFA (van den Berg et al., 2020). This strategy is limited in 1. that reliability was only guaranteed if the *a priori* risk of osteoporosis and/or fractures is low, i.e., women aged 50–70 years and 2. that a higher DI of $\geq$ 0.896 g/cm^2 was used (van den Berg et al., 2020).

Moreover, according to the UK guideline on osteoporosis (NICE), P-EU can be used to find those patients at increased risk for having osteoporosis (Bindex for investigating, 2017). A point of interest to evaluate is the effect of such a measurement performed soon after fracture comparing proportions FLS visits with or without prior P-EU analysis. Providing patient information with a visible measurement can provide additional motivation for a patient, a process also referred to in the literature as "nudging" (Hansen et al., 2016). Nudging can be used to create behavioral changes but also to encourage sustainable and safe choices. The beneficial effects of nudging depend on the strength of peoples' convictions and the setting of the nudge (National Institute for Pu, 2021).

The Dutch Health Institute reported in 2019 that 73.7% of the 2016 fracture cohort in the Netherlands, older than 50 years, never received a DXA/VFA between 12 months before and 12 months after the fracture. In addition, 50% of fracture patients invited to attend the FLS did not show up for DXA/VFA and a consultation (van den Berg et al., 2019; Eekman et al., 2014). Because of the COVID-19 pandemic, hospital policies regarding secondary prevention strategies have radically changed. Secondary fracture prevention care is therefore kept to a minimum, which means less DXA/VFA assessments and use of waiting lists. In order to address this additional problem on top of the previously reported huge gap of DXA/VFA scans, we decided to introduce P-EU in the plaster room of our hospital.

1.1. Study objectives

The first objectives of this study was to calculate the number of DXA/VFA scans avoided based on low fracture risk as determined by P-EU applied in the plaster room. Second, to analyze whether P-EU in this setting could encourage (nudge) more patients-at-high-risk of subsequent fractures to make an appointment for a DXA/VFA scan.

2. Patients and methods

In this retrospective study, we analyzed two cohorts of fracture patients older than 50 years. It is the policy of Reinier de Graaf Hospital, Delft, The Netherlands to offer every fracture patient in this age group a DXA/VFA scan and a consultation with the Fracture Liaison Service (FLS). The intention to continue as much patient care as possible in spite of COVID-19 restrictions. Initially, the flow of patients invited and seen by our team almost stopped due to strict lockdown periods. Over time, however, the flow of patients gradually returned. At last, the COVID-19 cohort included 1056 patients (peri-COVID-19; from March 1, 2020 to February 28, 2021). A year prior, a total of 1307 patients were included (pre-COVID-19 cohort; February 1, 2019 to March 1, 2020). Retrospective identification of eligible patients was as follows: each consecutive patient was identified weekly based on fracture code exit registrations and included for analysis. Excluded were patients with finger, toe, or skull fractures, deceased patients, patients with malignancies, permanent nursing home residents, patients already on anti-osteoporosis treatment (not including calcium or vitamin D), or those who had a DXA within the past two years.

In this study, we focused on those patients who needed plaster treatment. Fracture types treated in plaster were (toe), metatarsal, tarsal, calcaneal, fibula, and tibia, (finger), metacarpal, carpal, radius, ulna, humeral condyle, and distal humeral shaft fractures. Obviously, vertebral, hip, pelvic and subcapital humerus fractures are not treated with plaster. Each fracture was categorized in low risk (non-vertebral/non-hip minor, non-vertebral/non-hip major, hip, and vertebral fractures (VFs) according to Warriner (Warriner et al., 2011).

As soon as possible after the fracture, each patient in need of plaster treatment received information in the plaster room from one of the nurse technicians. Patients with fractures who did not require in-plaster treatment did not receive face-to-face patient information. Soon after discharge, these patients received an invitation letter at home with the request to make an appointment for a DXA/VFA scan and to go to the FLS. During COVID-19, each plaster room patient received the same face-to-face patient information but also an ultrasound assessment. The result of the scans was also shared with the patients. Like in the Pre-COVID-19 cohort, it was our policy to remind each individual who did not comply with diagnostic workup with a DXA/VFA scan (taking into account delays caused by COVID-19 restrictions). Regrettably, during the first strict lockdown period in the Netherlands in March until June 2020, several intentionally attendees (responders) were put on a waiting list for DXA/VFA.

The P-EU device was kept in the plaster room and used only there. For the analysis on saving unnecessary DXA/VFA scans, we only included women between 50 and 70 years who were treated with plaster. The decision threshold to "rule out" was based on the optimal threshold (Density Index (DI)) as previously published in women of 50–70 years (van den Berg et al., 2020).

The most important item in the patient information was the increased risk of a subsequent fracture after the current fracture and the need for prevention. Patient information was not static, but tailored made, based on the understanding of the patient, family or caregivers. The Pre-COVID-19 and Peri-COVID-19 cohorts were therefore similarly approached in the plaster room with one exception whether they underwent P-EU.

To analyze our hypothesis that patient information in combination with P-EU would increase number of DXA/VFA scans (via a nudging effect), we compared the proportion of performed DXA/VFA scans between Pre-COVID-19 (P-EU-) and Peri-COVID -19 (P-EU+) groups.

Patient characteristics of both cohorts are shown in Table 1. Gender, age, fracture type and treatments were similarly distributed in both cohorts (pre-COVID-19 cohort: 70% women and 30% men, mean age 69 years; peri-COVID-19 cohort: 68% women and 32% men, mean age 70 years). Distribution of fracture type (pre- and peri-COVID-19) was similar across cohorts and showed approximately one minor fracture against every two major fractures, and in-plaster treatment occurred in half of patients in both cohorts.

During the COVID-19 part of the study, each person attending the plaster room received an ultrasound assessment. As mentioned in the introduction, the ultrasound used in this study was based on P-EU technology (Bindex®; Bone Index Finland, Kuopio, Finland (Karjalainen et al., 2012; Eneh et al., 2016; Karjalainen et al., 2016). We used a DI cut-off point greater or less than 0.896 g/cm^2 which was published as being optimal to exclude patient-defined t-score osteoporosis and/or prevalent vertebral fractures (Genant grade II/III). In this FLS-initiated study with Bindex®, a DI $<$ 0.896 g/cm^2 led us to recommend additional testing with DXA/VFA, whereas in the case of a DI $\geq$ 0.896 g/cm^2 no further DXA/VFA was considered necessary in women aged 50–70 years (van den Berg et al., 2020). P-EU scans could not be made in 2 women between 50 and 70 years due to technical problems and in 4 older patients because of leg edema.

Table 1
Characteristics of Dutch fracture patients in two cohorts (pre-COVID-19 period, February 2019 until March 2020, and peri-COVID-19 period, from March 2020 until February 2021) identified at the emergency department and plaster room.

	Cohort 1 pre-COVID-19 period N = 1307	Cohort 2 peri-COVID-19 period N = 1056
Gender		
Men	397 (30.4%)	335 (31.7%)
Women	910 (69.6%)	721 (68.3%)
Age group		
50–70 yrs.	734 (56.2%)	528 (50.0%)
>70 yrs.	573 (43.8%)	528 (50.0%)
Age		
Mean (SD)	68.7 (10.9)	70.2 (11.7)
Range	50–96	50–98
Fracture		
Minor	499 (38.2%)	369 (34.9%)
Major	592 (45.3%)	495 (46.9%)
Hip	161 (12.3%)	149 (14.1%)
Vertebra	55 (4.2%)	43 (4.1%)
Treatment		
plaster	726 (55.5%)	523 (49.5%)
other	581 (44.5%)	533 (50.5%)
DXA/VFA scan		
No	533 (40.8%)	513 (48.6%)
Yes	774 (59.2%)	543 (51.4%)

2.1. *Statistical methods*

Contingency table analyses were conducted to assess the degree of association between cohort and the proportion of patients receiving (or ruling out) a DXA/VFA scan. Null hypothesis significance testing was based on the Chi-square test, in which the significance level was set to 0.05. Effect size was estimated as the difference between binomial proportions (risk difference), complemented with 95% confidence intervals (95% CI). Confidence intervals for proportions and for the difference between independent proportions were calculated by means of Wilson score/Newcombe's method (Newcombe, 1998a, 1998b). In addition, calculated from the difference between proportions and its confidence interval, effect size was also expressed in terms of the number needed to treat (NNT), being the number of patients that need to be exposed to an intervention to get one additional patient with a favorable outcome. The study was carried out in accordance with Good Clinical Practice (GCP) following the Medical Ethical Review Board decision of no objection (METC Zuid West Holland) no. 16.190.

3. Results

Two study episodes, before (pre-COVID-19 cohort) and during the COVID-19 pandemic (peri-COVID-19 cohort), were analyzed, see Fig. 1 (flow chart). During the lockdown, the monthly patient number decreased on average leading to 19% fewer fracture patients who visited the hospital during 2020. The number of fractures categorized according to Warriner (Warriner et al., 2011) was for non-vertebral/non-hip minor fractures 499 (38%) and for non-vertebral/non-hip major, hip, and VFs 808 (62%) in pre-COVID-19, while it was 369 (35%) and 687 (65%) in peri-COVID-19, respectively.

The pre-COVID-19 number of patients who received plaster was 328 women and 132 men aged 50–70 years, and 214 women and 52 men older than 70 years. For the peri-COVID-19 patients it was 204 women and 94 men (50–70), and 182 women and 43 men (>70 years).

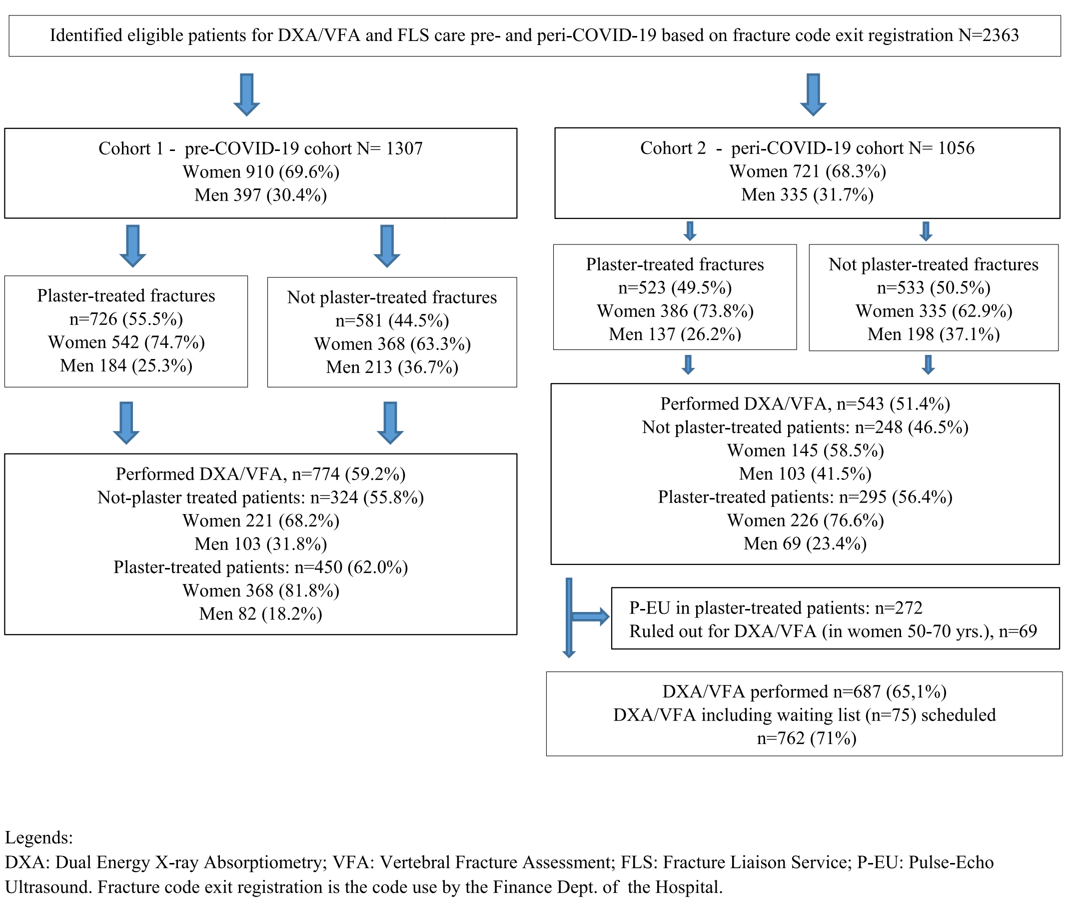

Fig. 1. Flowchart of the study.
Legends:DXA: Dual Energy X-ray Absorptiometry; VFA: Vertebral Fracture Assessment; FLS: Fracture Liaison Service; P-EU: Pulse-Echo Ultrasound. Fracture code exit registration is the code use by the Finance Dept. of the Hospital.

3.1. The number of spared DXA/VFA scans based on a P-EU threshold value of DI ≥ 0.896 g/cm^2

69 women had a negative test (DI ≥ 0.896 g/cm^2) and were ruled out for further DXA/VFA scans. Based on a total of 134 P-EU assessments in plaster-treated women of 50–70 years, this represents saving of DVA/VFA scans of 51.5% (69/134). If the calculation is based on all plaster-treated women between 50 and 70 years, it was 36% (69/191), and if based on all women aged 50–70 years both treated in plaster casts and not treated in plaster casts, it was 27% (69/253). If compared with published data (with P-EU assessments performed immediately post-DXA/VFA in all women 50–70 years), irrespectively of treatment in plaster, the current data obtained from female plaster room attendees 50–70 years it was 19.1%, 95%CI (14.4–25.0) against 27.3%, 95%CI (22.2–33.1). The difference between these proportions was 8.1%, 95%CI (0.3–15.6); P = .040, see Table 2.

3.2. P-EU use in the plaster room to persuade patients to have a DXA/VFA scan

Pre-COVID-19, 1307 patients were invited to attend for DXA/VFA scanning revealing an attendance of 59.2% (774/1307) while peri-Covid-19, a group of 618 out of 1056 patients (58.5%) received a DXA/VFA assessment.

Due to the lockdown, attendance was only calculated for DXA/VFA scanning either done or to be done as soon as possible (waiting list registrants). We had a total of 75 waiting list registrations. Three months after the study had ended, it appeared that all patients on the waiting list had a DXA/VFA performed.

As can be seen in Table 3, proportion-wise more DXA/VFA scans were performed peri-COVID-19 than pre-COVID-19. This nudging effect of P-EU exposure in the plaster room was statistically significant, P = .002. The effect size (expressed as the difference between proportions) was 5.8%, 95%CI (1.9–9.7). Expressed as NNT, we found that it took 18 patients who also received P-EU in the plaster room to gain one extra DXA/VFA scan, 95%CI (11–53).

The nudging effect was also calculated for the group of all plaster room attendees only (women aged 50–70 years, women over 70 years old, and men).

The two cohorts were again compared for the number of DXA/VFA scans performed (see Table 4), showing that proportionally more DXA/VFA scans were performed peri-COVID-19 than pre-COVID-19. These proportions increased from 62.0%, 95%CI (58.4–65.4) to 70.7%, 95%CI (66.7–74.5). The statistically significant difference in proportions was 8.8%, 95%CI (3.4–13.9); P = .001, with a NNT of 12, 95%CI (8–30).

4. Discussion

This retrospective study included 2 patient cohorts, a pre- and peri-COVID-19 pandemic cohort. P-EU assessments were performed in 50–70 years old women with the intention to spare unnecessary DXA/VFA scans, whereas in all plaster room patients we tried to induce a nudge effect to persuade more patients to consent with a DXA/VFA scan. The Density Index (DI) used as threshold to decide whether women of 50–70 years could skip further diagnostics (DXA/VFA) was based on our FLS-initiated pilot study (van den Berg et al., 2020). The use of a DI of ≥ 0.896 g/cm^2 being optimal for the ''ruling out purpose'' saved >19% unnecessary DXA/VFA scans in women aged 50–70 years, irrespective of fracture type. As an undesired effect of lockdown, we were facing restricted post-fracture care (Peeters et al., 2021). Despite this notion, the proportion of DXA/VFA scans performed was significantly higher during COVID-19 and significantly more patients became convinced to undergo DXA/VFA scanning. There may be several explanations for this phenomenon, like differences in behavior of fracture patients during a pandemic, earlier timing and perhaps more consistent patient information during plaster treatment, or patient information combined with the outcome results of a measurement.

P-EU test results have previously been shown to reliably rule out osteoporosis and/or prevalent VFs but only in women after a fracture aged 50–70 years (van den Berg et al., 2020). In that former study, the result of DXA/VFA was compared to that of P-EU in all these FLS attendees independently of plaster therapy, and the most reliable triage was achieved with a threshold value (DI) of ≥ 0.896 g/cm^2 sparing 19% DXA/VFA scans. However, the yield in the current plaster room cohort was remarkably better. The quantity of improved yield (between 27 and 51%) depended clearly on different calculation methods. In fact, the most realistic scenario is to calculate the outcome of the intervention only based on all women who received plaster cast treatment. In this scenario we spared 31% DXA/VFA capacity. Note that 19% sparing as published earlier by our group was only based on women aged 50–70 years with small and large fractures, either treated in plaster or not.

From a strategic point of view, FLSs are increasingly used to identify, invite, analyze, and treat patients at high risk of subsequent fractures. Several sociodemographic factors related to the FLS nonattendance have been identified like male gender, frailty, living alone, having low general education, or low interest in bone health (van den Berg et al., 2019). Apart from, adequately perceived advice (to have a bone densitometry and attend the FLS) was strongly associated with FLS attendance (van den Berg et al., 2019). This was the reason for us to use P-EU in all patients in the plaster room. We hypothesized that the combination of

Table 2
Yield of P-EU-based ruling out of redundant DXA/VFA scans for female fracture patients 50–70 yrs by applying a DI > 0.896 g/cm2 during the peri-COVID-19 period.

	**P-EU Cohort Women 50–70 yrs. N = 591	Cohort 2 peri-COVID-19 period present study N = 1056	Difference in proportions (95% CI)	P value
Ruled out				
Yes	40 (19.1%)	69 (27.3%)	8.1% (0.3; 15.6)	.040
No	169 (80.9%)	184 (72.7%)		
Total	209	253		

**P-EU Cohort Women 50–70 yrs. Van den Berg et al. (van den Berg et al., 2020)

Table 3
DXA/VFA scans performed in the pre- and peri-COVID-19 cohorts. All fracture patients were included. Addition of 69 ruled-out women of 50–70 yrs is taken in account (618 + 69 = 687 (65.1%)). Each empty DXA/VFA slot was used on a consecutive patient.

	Cohort 1 pre-COVID-19 periodN = 1307	Cohort 2 peri-COVID-19 periodN = 1056	Difference in proportions (95% CI)	P value
DXA/VFA scan				
Yes	774 (59.2%)	687 (65.1%)	5.8% (1.9; 9.7)	.002
No	533 (40.8%)	369 (34.9%)		
Total	1307	1056		

Table 4
DXA/VFA scans performed in pre- and peri-COVID-19 cohorts. Only plaster room attendees were included. Addition of 69 ruled-out women of 50–70 yrs is taken in account (301 + 69 = 370 (70.7%)). Each empty DXA/VFA slot was used on a consecutive patient.

	Cohort 1 pre-COVID-19 periodN = 1307	Cohort 2 peri-COVID-19 periodN = 1056	Difference in proportions (95% CI)	P value
DXA/VFA scan				
Yes	450 (62.0%)	370 (70.7%)	8.8% (3.4; 13.9)	.001
No	276 (38.0%)	153 (29.3%)		
Total	726	523		

patient information in combination with P-EU would be a sufficiently strong nudge for DXA/VFA attendance.

Nudging in healthcare is a delicate initiative to encourage patients to make the right choices about their physical and psychological health with the aim of preventing illness and improving their quality of life (QoL). Patient's choice after nudging is always based on free decision making (Leonard et al., 2008). "A nudge" can be any small stimulus in the environment that attracts our attention and alters our behavior" (Leonard et al., 2008). Nudging is widely recognized and accepted in health care to enhance intrinsic motivation in the interest of the individual through external nudges (Harrison and Patel, 2020). In the peri-COVID-19 cohort, 70.7% of all plaster patients had a DXA/VFA scan, while in the pre-COVID-19 cohort 62% had a DXA/VFA scan (56% were plaster room patients).

The strength of the study is that it confirms both our hypotheses: a DXA/VFA sparing effect, stronger compared to the outcome of a previous study from our group (set-up as a first pilot among women at low risk of having osteoporosis based on age category (50–70 years)) and a nudging effect, which was demonstrated for the first time. We belief that both aspects are of great importance for individual patients but also from a health economic perspective. The nudge effects can be explained by the early timing of P-EU, almost immediately after fracture during plaster treatment.

This study contains two clear weaknesses: 1. its retrospective design and 2. the use of fixed DI cut-off to decide to rule out for DXA/VFA in women aged 50–70 years. It remains to be seen whether time of P-EU is optimal in the plaster room. Anxiety and pain can be confounders whereby the nudging effect is wrongly attributed to the application of P-EU. A future RCT in the plaster room is necessary to determine this definitively.

In our strive to continue secondary fracture prevention we studied P-EU in the plaster room. This effort is in line with the 5-steps approach of FLSs to facilitate the diagnostic process of the FLS (Van Den Bergh et al., 2012). Future research is imperative to study decision thresholds not only in women aged 50–70 years, but also in elderly women and in men. In these different groups we should study optimal P-EU cut-off points in rule-out strategies, but at the same time we should also consider challenges and opportunities of the nudging effect through the same intervention.

To conclude, we had a Covid-19 given opportunity to use P-EU in the plaster room to continue secondary fracture prevention care. It generated two effects: the appropriate sparing of a substantial portion of DXA/VFA scans in women aged 50–70 years and nudging effect interesting more plaster patients to undergo a diagnostic work-up with a DXA/VFA scan. This study therefore demonstrates new possibilities to optimize access to the FLS for those who need it.

Ethical statement

The study was carried out in accordance with Good Clinical Practice (GCP) following the Medical Ethical Review Board decision of no objection (METC Zuid West Holland) no. 16.190.

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Martin van Leerdam: no disclosures.
Dave H. Schweitzer: no disclosures.

Declaration of competing interest

Peter van den Berg, Martin van Leerdam, and Dave Schweitzer declare that they have no conflict of interest.

References

Åkesson, K., Marsh, D., Mitchell, P.J., et al., 2013. Capture the Fracture: a Best Practice Framework and global campaign to break the fragility fracture cycle. Osteoporos. Int. 24, 2135–2152. https://doi.org/10.1007/s00198-013-2348-z.

Balasubramanian, A.A., Zhang, J., Chen, L., et al., 2019. Risk of subsequent fracture after prior fracture among older women. Osteoporos. Int. 30, 79–92. https://doi.org/10.1007/s00198-018-4732-1.

Banefelt, J., Åkesson, K.E., Spångéus, A., et al., 2019. Risk of imminent fracture following a previous fracture in a Swedish database study. Osteoporos. Int. 30, 601–609. https://doi.org/10.1007/s00198-019-04852-8.

2017) Bindex for Investigating Suspected Osteoporosis Medtech Innovation Briefing.

Conley, R.B., Adib, G., Adler, R.A., et al., 2020. Secondary fracture prevention: consensus clinical recommendations from a multistakeholder coalition. J. Bone Miner. Res. 35, 36–52. https://doi.org/10.1002/jbmr.3877.

Dreinhöfer, K.E., Mitchell, P.J., Bégué, T., et al., 2018. A global call to action to improve the care of people with fragility fractures. Injury 49, 1393–1397. https://doi.org/10.1016/j.injury.2018.06.032.

Eekman, D.A., Van Helden, S.H., Huisman, A.M., et al., 2014. Optimizing fracture prevention: the fracture liaison service, an observational study. Osteoporos. Int. 25, 701–709. https://doi.org/10.1007/s00198-013-2481-8.

Eisman, J.A., Bogoch, E.R., Dell, R., et al., 2012. Making the first fracture the last fracture: ASBMR task force report on secondary fracture prevention. J. Bone Miner. Res. 27, 2039–2046.

Eneh, C.T.M., Malo, M.K.H., Karjalainen, J.P., et al., 2016. Effect of porosity, tissue density, and mechanical properties on radial sound speed in human cortical bone. Med. Phys. 43, 2030–2039. https://doi.org/10.1118/1.4942808.

Giangregorio, L., Thabane, L., Cranney, A., et al., 2010. Osteoporosis knowledge among individuals with recent fragility fracture. Orthop. Nurs. 29, 99–107. https://doi.org/10.1097/NOR.0b013e3181d2436c.

Grover, M.L., Edwards, F.D., Chang, Y.H.H., et al., 2014. Fracture risk perception study: patient self-perceptions of bone health often disagree with calculated fracture risk. Wom. Health Issues 24. https://doi.org/10.1016/j.whi.2013.11.007.

Hansen, P.G., Skov, L.R., Skov, K.L., 2016. Making healthy choices easier: regulation versus nudging. Annu. Rev. Publ. Health 37, 237–251. https://doi.org/10.1146/annurev-publhealth-032315-021537.

Harrison, J.D., Patel, M.S., 2020. Medicine and society: designing nudges for success in health care. AMA J. Ethics 22, 796–801. https://doi.org/10.1001/amajethics.2020.796.

Karjalainen, J.P., Riekkinen, O., Töyräs, J., et al., 2012. Multi-site bone ultrasound measurements in elderly women with and without previous hip fractures. Osteoporos. Int. 23, 1287–1295. https://doi.org/10.1007/s00198-011-1682-2.

Karjalainen, J.P., Riekkinen, O., Töyräs, J., et al., 2016. New method for point-of-care osteoporosis screening and diagnostics. Osteoporos. Int. 27, 971–977. https://doi.org/10.1007/s00198-015-3387-4.

Lems, W.F., Dreinhöfer, K.E., Bischoff-Ferrari, H., et al., 2017. EULAR/EFORT recommendations for management of patients older than 50years with a fragility fracture and prevention of subsequent fractures. Ann. Rheum. Dis. 76, 802–810. https://doi.org/10.1136/annrheumdis-2016-210289.

Leonard, T.C., Richard, H. Thaler, Cass, R. Sunstein, 2008. Nudge: improving decisions about health, wealth, and happiness. Const. Polit. Econ. 2008 194, 356–360. https://doi.org/10.1007/S10602-008-9056-2, 19.

McLellan, A.R., Gallacher, S.J., Fraser, M., McQuillian, C., 2003. The fracture liaison service: success of a program for the evaluation and management of patients with osteoporotic fracture. Osteoporos. Int. 14, 1028–1034. https://doi.org/10.1007/s00198-003-1507-z.

National Institute for public health and the environment | RIVM. https://www.rivm.nl/en. Accessed 1 Aug 2021.

Newcombe, R.G., 1998a. Two-sided confidence intervals for the single proportion: comparison of seven methods. Stat. Med. 17, 857–872. https://doi.org/10.1002/(SICI)1097-0258(19980430)17:8<857::AID-SIM777>3.0.CO, 2-E.

Newcombe, R.G., 1998b. Interval estimation for the difference between independent proportions: comparison of eleven methods. Stat. Med. 17, 873–890. https://doi.org/10.1002/(SICI)1097-0258(19980430)17:8<873::AID-SIM779>3.0.CO;2-I.

Peeters, J.J.M., van den Berg, P., van den Bergh, J.P., et al., 2021. Osteoporosis care during the COVID-19 pandemic in The Netherlands: a national survey. Arch. Osteoporos. 16 https://doi.org/10.1007/S11657-020-00856-8.

Raybould, G., Babatunde, O., Evans, A.L., et al., 2018. Expressed information needs of patients with osteoporosis and/or fragility fractures: a systematic review. Arch. Osteoporos. 13.

van den Berg, P., van Haard, P.M.M., Geusens, P.P., et al., 2019. Challenges and opportunities to improve fracture liaison service attendance: fracture registration and patient characteristics and motivations. Osteoporos. Int. 30 https://doi.org/10.1007/s00198-019-05016-4.

van den Berg, P., Schweitzer, D.H., van Haard, P.M.M., et al., 2020. The use of pulse-echo ultrasound in women with a recent non-vertebral fracture to identify those without osteoporosis and/or a subclinical vertebral fracture: a pilot study. Arch. Osteoporos. 15 https://doi.org/10.1007/s11657-020-00730-7.

Van Den Bergh, J.P., Van Geel, T.A., Geusens, P.P., 2012. Osteoporosis, frailty and fracture: implications for case finding and therapy. Nat. Rev. Rheumatol. 8, 163–172.

van Geel, T.A.C.M., van Helden, S., Geusens, P.P., et al., 2009. Clinical subsequent fractures cluster in time after first fractures. Ann. Rheum. Dis. 68, 99–102. https://doi.org/10.1136/ard.2008.092775.

Warriner, A.H., Patkar, N.M., Yun, H., Delzell, E., 2011. Minor, Major, Low-Trauma, and high-trauma fractures: what are the subsequent fracture risks and how do they vary? Curr. Osteoporos. Rep. 9, 122–128. https://doi.org/10.1007/s11914-011-0064-1.