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Burden of screening and treatment of bone health markers amongst elderly patients with proximal femur fractures

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Abstract

Introduction : This study aims to quantify changes in the burden of screening for osteoporosis and vitamin D deficiency (VDD) amongst elderly patients treated with proximal femur fracture repair (PFFR).

Methods Data collection and analysis was performed via the TriNetX HCO group network titled Research. Patients aged 65 and older who underwent PFFR were included based on CPT codes. Rates of preexisting diagnoses of VDD and/or osteoporosis, and first-time diagnoses of VDD or osteoporosis at 1 month, 6 months, and 1 year following PFFR between 2004 and 2024 were explored. Patient demographics and comorbidity data were compared across patient cohorts using chi-square tests for categorical variables, independent samples t-tests for continuous variables. Standardized differences were used to calculate the effect size.

Results PFFRs registered in TriNetX have increased from 2004 to 2024 (Table 1). Those patients who underwent PFFR without prior history of VDD and/or osteoporosis ranged from 74.60% in 2004 to 49.83% in 2024. Conversely, patients with a prior history of documented VDD and/or osteoporosis ranged from 25.4% in 2004 to 50.1% in 2024. The percent risk of a first-time diagnosis of osteoporosis at 1 month, 6 months, and 1 year in the overall cohort were 3.7%, 8.6%, and 10.3%, respectively. The percent risk of a first-time diagnosis of VDD at 1 month, 6 months, and 1 year in the overall cohort were 2.1%, 4.4%, and 5.6%, respectively.

Conclusion The burden of screening for markers of bone health and subsequent treatment in at risk patients has increased over time. Rates of first-time diagnoses of osteoporosis or VDD after PFFR represent a current treatment burden of approximately 10% and 5% of this population at 1 year, respectively. This number may underrepresent the true burden of disease, highlighting the necessity of screening protocols targeting this population.

Keywords Bone health, Osteoporosis, Osteoporosis screening, Own the bone, TriNetX, Proximal femur fracture osteoporosis, Vitamin d deficiency

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Introduction

With a growing elderly population, the incidence of geriatric orthopedic trauma, including fragility fractures, is on the rise [1]. In 1990, there were approximately 1.31 million hip fractures worldwide, and this number is projected to exceed 6.26 million by 2050 [2]. Previous studies have estimated that the rate of osteoporosis in elderly patients who have sustained low energy hip fractures ranges from 41–48% [3–5]. With this increase in incidence in osteoporosis-related fracture comes an increased burden of screening for and treating osteoporosis [6] as well as the necessity for increased multidisciplinary collaboration to ensure at-risk patients are appropriately screened and treated. In addition to timely and appropriate surgical intervention for these injuries [2]including consideration for multidisciplinary hospital care [7, 8] there is a push for orthopedic surgeons to take more responsibility for considering patient health factors beyond the initial hospitalization [9]including screening and managing patient bone health, including osteoporosis pharmacological treatment, through programs such as the American Orthopaedic Association's "Own the Bone" initiative [10, 11]. These programs have been demonstrated to be effective at appropriately screening and pairing patients with treatment [12]. However, there exists little information on the anticipated volume of screening and treatment specific to those patients identified through these programs through connection to orthopedic care after identification of risk factors such as fragility fracture.

This study aims to quantify changes in the burden of screening for osteoporosis and vitamin D deficiency (VDD) amongst elderly patients treated for proximal femur fracture via surgical repair (PFFR), a known strong indicator of poor bone health, through analysis of those patients after PFFR who receive first-time diagnoses of osteoporosis or VDD up to one year after PFFR, through the TriNetX database.

Methods

Study design and data collection

Institutional Review Board approval was obtained to access the TriNetX (Cambridge, MA, USA) Research network through our institution. The Research network is a global research network that includes data from 104 healthcare organizations (HCOs) across 6 countries (United States, Brazil, Colombia, Georgia, India, and Taiwan) including approximately 140 million patients. Variables captured by this platform include demographics, medications, laboratory test values, diagnoses mapped to the International Classification of Diseases, 10th edition (ICD-10) coding and procedures mapped to Current Procedural Terminology (CPT) coding. Health Insurance Portability and Accountability Act (HIPAA)-compliant electronic health record data were collected from participating HCOs who submit structured and unstructured data. Cohorts were created using the "Query Builder" function, and data was generated on January 7, 2025.

Patients that were at least 65 years of age who underwent PFFR (CPT codes: 27230, 27232, 27235, 27236, 27244, 27245) within a specified year (i.e. 01/01/2024 to 12/31/2024), and who received hospital services within at least 1 week of repair ("Visit: Inpatient encounter" and CPT codes: 1013729, 1013699, 1013659) were included in the cohort for that year. Patients were split amongst two cohorts based on the presence or absence of osteoporosis (ICD-10 codes: M80 and M81) and/or VDD (ICD-10 code: E55). This allowed us to calculate the total number of PFFRs on an annual basis as well as the percentage of people each year who had PFFR with and without pre-existing osteoporosis and/or VDD. This also allowed us to explore differences in demographics and select comorbidities between these two cohorts.

A second analysis was performed for each year using only data from the cohort of patients that did not have a diagnosis of osteoporosis and/or VDD prior to their index PFFR. The "Analyze Outcomes" function on the TriNetX platform was used to calculate the percent risk of this group of patients receiving a first-time diagnosis of osteoporosis or VDD, one month, six months, and one year after undergoing surgical repair. Both analyses were also performed without the use of a time constraint. This allowed us to compare groups across all timepoints as well as generate overall percent risk of receiving a first-time diagnosis of osteoporosis or VDD following PFFR at one month, six months, and one year after surgery.

Statistical analysis

Continuous variables were compared using 2-tailed independent samples t-tests and are represented as means and standard deviations. Categorical variables were compared using chi-square or Fisher's exact tests and are represented by their numbers and percentages of the sample size. TriNetX uses the standardized difference to quantify the effect size of each comparative test for both continuous and categorical variables. For all statistical analyses, a significance level of $\alpha < 0.05$ was used.

Results

The total number of proximal femur fractures registered in TriNetX has exponentially increased from 2004 to 2024, with 11,506 proximal femur fracture repairs in 2024. In 2024, 5,625 PFFR were without prior history vs. 5,881 had prior history of VDD and/or osteoporosis; those patients who underwent PFFR without prior history of VDD and/or osteoporosis ranged from 74.60% in 2004 to 49.83% in 2024. Conversely, those patients with

a prior history of documented VDD and/or osteoporosis ranged from 25.4% in 2004 to 50.1% in 2024 (Table 1).

Table 2 describes patient demographics across these cohorts combined over time. While comparisons of many of the described patient demographics were significant between those with and without preexisting diagnosis of osteoporosis or VDD, effect sizes were low, and these differences were thought to not be clinically relevant. Demographics with the highest effect size included osteoarthritis (0.486), preexisting spondylopathy (0.469), and anxiety (0.409).

Of those patients without preexisting diagnosis of osteoporosis at time of PFFR at all time points, Fig. 1 illustrates the number of patients who received a first-time diagnosis of osteoporosis in 1 month, 6 months, or 1 year after PFFR at all time points. Figure 2 illustrates the percent risk of first-time diagnosis of osteoporosis amongst this cohort at each time point up to 1 year. The percent risk of a first-time diagnosis of osteoporosis at 1 month, 6 months, and 1 year in the overall cohort were 3.7%, 8.6%, and 10.3% respectively.

Of those patients without preexisting diagnosis of VDD at time of PFFR at all time points, Fig. 3 illustrates the number of patients who received a first-time diagnosis of VDD in 1 month, 6 months, or 1 year after PFFR at all time points. Figure 4 illustrates the percent risk of first-time diagnosis of VDD amongst this cohort at each time point up to 1 year. The percent risk of a first-time diagnosis of VDD at 1 month, 6 months, and 1 year in the overall cohort were 2.1%, 4.4%, and 5.6%, respectively.

Discussion

Risk factors for poor bone health include history of atraumatic fractures of the femur, distal radius, or vertebral column, family history of bone disease, low body weight, chronic glucocorticoid use, height loss, and thyroid diseases especially those requiring treatment with high doses of thyroid hormone [13]. The U.S. Preventive Services Task Force (USPSTF) recommends the use of dual-energy x-ray absorptiometry (DEXA) scan to screen for osteoporosis in women 65 years or older, as well as in postmenopausal women younger than 65 years who are at an increased risk for osteoporotic fractures as estimated by the FRAX Fracture Risk Assessment Tool. The USPSTF has graded this recommendation with a 'B,' indicating that there is a high certainty that the net benefit of screening is moderate to substantial. There remains insufficient evidence to recommend screening for osteoporosis in men [14]. Screening for VDD via blood serum 25-hydroxyvitamin D levels demonstrating levels below 20ng/mL have shown an association with a high risk of acquiring osteoporosis [15]. However, identifying fragile patients before the development of a fracture represents a clinical challenge [16]. A recent analysis proposed body weight as a more accurate predictor of osteoporosis compared to BMI or age amongst women over the age of 50,

Table 1 Number of patients 65 and older with proximal femur fracture repairs registered in the TriNetX research network (2004–2024)

Year	Total PFFR (*n* = 69282)	PFFR without history of VDD and/or osteoporosis (*n*)	PFFR without history of VDD and/or osteoporosis (%)	PFFR with history of VDD and/or osteoporosis (*n*)	PFFR with history of VDD and/or osteoporosis (%)
2024	11,506	5625	48.9%	5881	51.1%
2023	10,609	5289	49.9%	5320	50.2%
2022	9674	5116	52.9%	4558	47.1%
2021	7738	4145	53.6%	3593	44.1%
2020	6453	3524	54.6%	2929	45.4%
2019	5531	3116	56.3%	2415	43.7%
2018	4665	2785	59.7%	1880	40.3%
2017	3501	2117	60.5%	1384	39.5%
2016	2500	1611	64.4%	889	35.6%
2015	1841	1143	62.1%	698	37.9%
2014	1443	920	63.8%	523	36.2%
2013	1072	706	65.9%	366	34.1%
2012	771	550	71.3%	221	28.7%
2011	606	441	72.8%	165	27.2%
2010	445	315	70.8%	130	29.2%
2009	260	179	68.9%	81	31.2%
2008	267	186	69.7%	81	30.3%
2007	208	154	74.0%	54	26.0%
2006	129	93	72.1%	36	27.9%
2005	63	47	74.6%	16	25.4%
2004	0	0	00.0%	0	00.0%

Table 2 Patient demographics and Pre-existing comorbidities at all time points

Overall total (*n* = 62774)	**No prior diagnosis of osteoporosis or VDD (*n* = 34693)**		**Some prior diagnosis of VDD/osteoporosis (*n* = 27453)**		***P*-Value**	**Effect size**
Age (mean ± SD)	76.6	6.36	77.6	6.30	< 0.001	0.152
Gender (n, %)						
Male	14,056	40.9%	6474	22.8%	< 0.001	0.372
Female	18,694	54.3%	20,425	72.0%	< 0.001	0.395
Race (n, %)						
White	27,709	80.5%	23,382	82.4%	< 0.001	0.048
Black/African American	1989	5.8%	1377	4.9%	< 0.001	0.041
Asian	869	2.5%	706	2.5%	0.766	0.002
Native American or Alaska Native	73	0.2%	51	0.2%	0.363	0.007
Native Hawaiian or Other Pacific Islander	43	0.1%	69	0.2%	0.001	0.028
Ethnicity (n, %)						
Not Hispanic or Latino	27,852	81.0%	23,551	83.1%	< 0.001	0.054
Hispanic or Latino	1298	3.8%	873	3.1%	< 0.001	0.038
Pre-existing comorbidities (n, %)						
Atherosclerotic heart disease of native coronary artery with angina pectoris	1361	4.0%	1657	5.8%	< 0.001	0.087
Angina pectoris	1581	4.6%	2071	7.3%	< 0.001	0.115
Anxiety, dissociative, stress-related, somatoform and other nonpsychotic mental disorders	7760	22.6%	11,774	41.5%	< 0.001	0.415
Osteoarthritis	10,814	31.4%	15,561	54.9%	< 0.001	0.487
Other rheumatoid arthritis	931	2.7%	1914	6.8%	< 0.001	0.191
Other arthritis	302	0.9%	600	2.1%	< 0.001	0.102
Rheumatoid arthritis with rheumatoid factor	169	0.5%	552	2.0%	< 0.001	0.133
Pyogenic arthritis	199	0.6%	263	0.9%	< 0.001	0.040
Asthma	2220	6.4%	3720	13.1%	< 0.001	0.226
Atrial fibrillation and flutter	7534	21.9%	6969	24.6%	< 0.001	0.063
Neoplasms	10,794	31.4%	14,335	50.5%	< 0.001	0.397
Chronic kidney disease (CKD)	7519	21.9%	8457	29.8%	< 0.001	0.183
Other chronic obstructive pulmonary disease	6557	19.1%	7039	24.8%	< 0.001	0.139
Atherosclerotic heart disease of native coronary artery	9765	28.4%	9435	33.3%	< 0.001	0.106
Cervical disc disorders	1784	5.2%	3024	10.7%	< 0.001	0.204
Thoracic, thoracolumbar, and lumbosacral intervertebral disc disorders	3278	9.5%	6325	22.3%	< 0.001	0.355
Spondylopathies	6814	19.8%	11,348	40.0%	< 0.001	0.452
Unspecified dementia	5125	14.9%	5566	19.6%	< 0.001	0.125
Dementia in other diseases classified elsewhere	2556	7.4%	3037	10.7%	< 0.001	0.114
Vascular dementia	860	2.5%	1278	4.5%	< 0.001	0.109
Alzheimer's disease	1891	5.5%	2292	8.1%	< 0.001	0.103
Depressive episode	7016	20.4%	10,471	36.9%	< 0.001	0.372
Diabetes mellitus	9682	28.1%	8814	31.1%	< 0.001	0.064
Essential (primary) hypertension	21,861	63.5%	21,533	75.9%	< 0.001	0.271
Heart failure	7378	21.5%	7665	27.0%	< 0.001	0.130
Acute myocardial infarction	3198	9.3%	3544	12.5%	< 0.001	0.103
Old myocardial infarction	3241	9.4%	3304	11.7%	< 0.001	0.726
Peripheral vascular disease, unspecified	3261	9.5%	3965	14.0%	< 0.001	0.140
Cerebral infarction	3419	9.9%	3784	13.3%	< 0.001	0.106
Other and unspecified nontraumatic intracranial hemorrhage	784	2.3%	798	2.8%	< 0.001	0.034
Visual disturbances and blindness	2491	7.2%	4401	15.5%	< 0.001	0.263
Conductive and sensorineural hearing loss	1622	4.7%	3312	11.7%	< 0.001	0.256
Disturbances of skin sensation	2234	6.5%	4460	15.7%	< 0.001	0.297
Abnormalities of gait and mobility	4681	13.6%	8086	28.5%	< 0.001	0.372

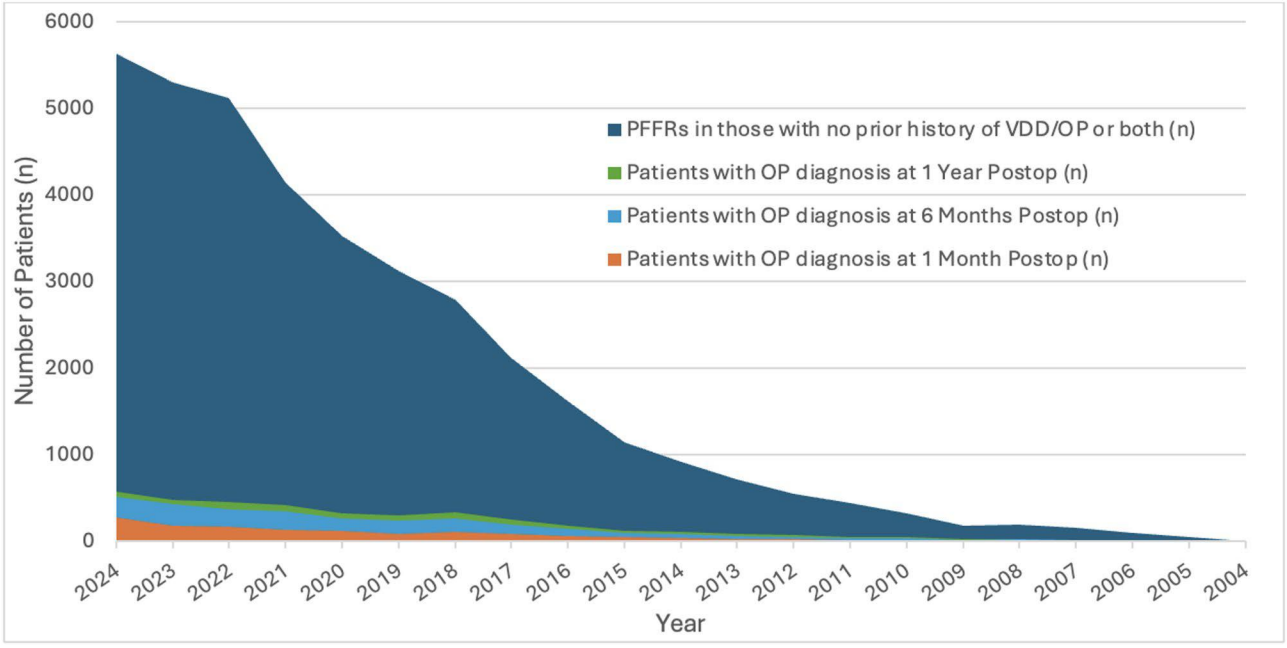

Fig. 1 Number of patients 65 + who received a first-time diagnosis of osteoporosis (OP) in 1 month, 6 months, or 1 year after PFFR (2004–2024)

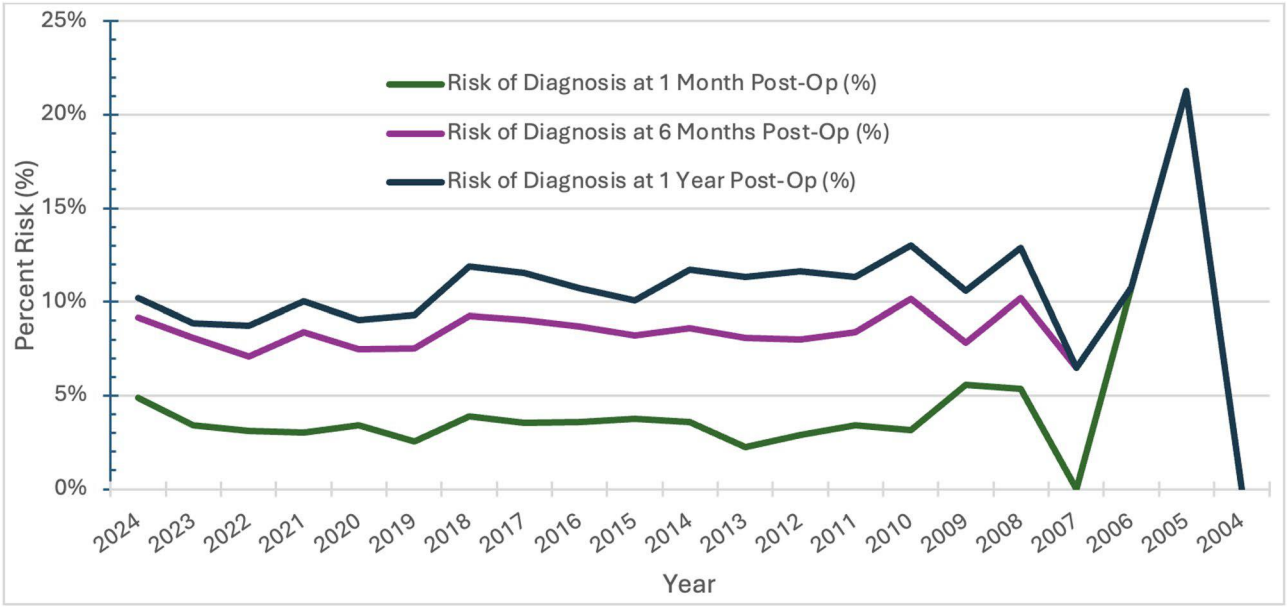

Fig. 2 Percent risk of first-time diagnosis of osteoporosis (OP) in those 65 + at 1 month, 6 months, or 1 year after PFFR (2004–2024)

which may call for changes to the current gold standard cut-off values of BMI and age that have previously been used to guide screening [17]. Regardless, any patient aged 60 and older with non-vertebral fragility fractures should be evaluated to ensure timely diagnosis and intervention [18]. After osteoporosis is diagnosed, first-line management includes adequate calcium intake (1200 mg/day for women 51 years and older and men 71 years and older), adequate vitamin D intake (800–1000 units for adults 50 years and older), smoking cessation, weight-bearing exercises, and bisphosphonates [19].

Elderly patients specifically presenting with low energy proximal femur fracture who undergo surgical treatment, as in our cohort, should be screened for potential concomitant osteoporosis and/or VDD. An estimated two-thirds of patients older than 50 years of age with prior fragility fractures have a bone mineral density T-score of less than − 1.0 [20]. Similarly, a study conducted by Han et al., showed that 610 out of 732 total patients (83.3%)

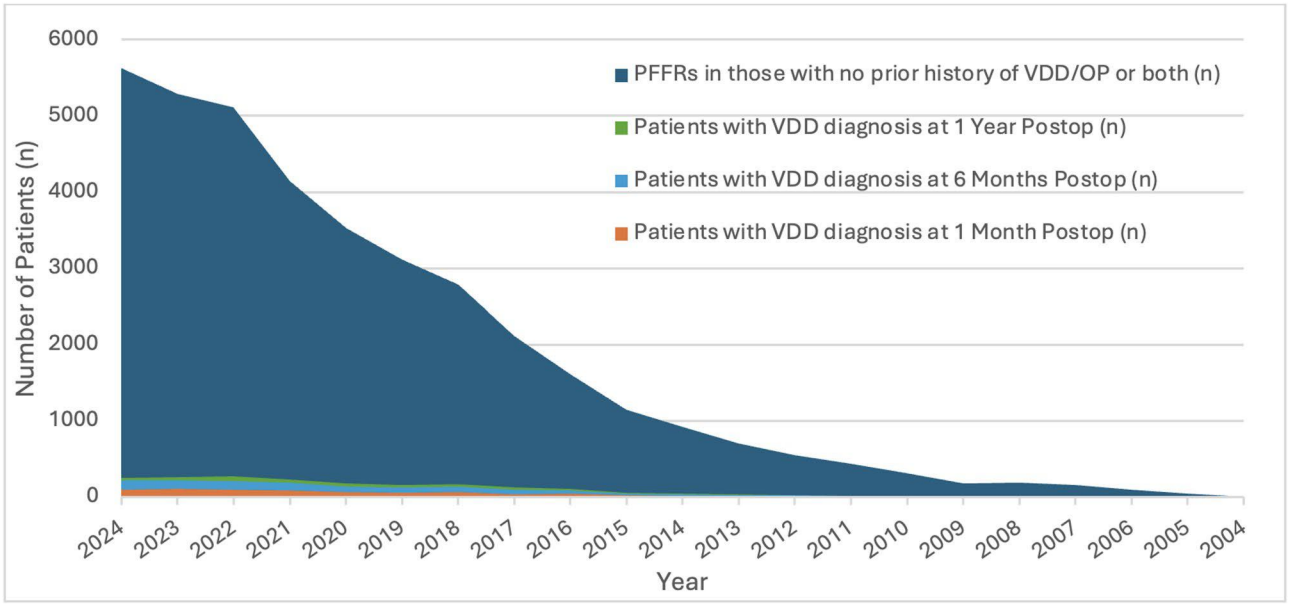

Fig. 3 Number of patients 65 + who received a first-time diagnosis of VDD in 1 month, 6 months, or 1 year after PFFR (2004–2024)

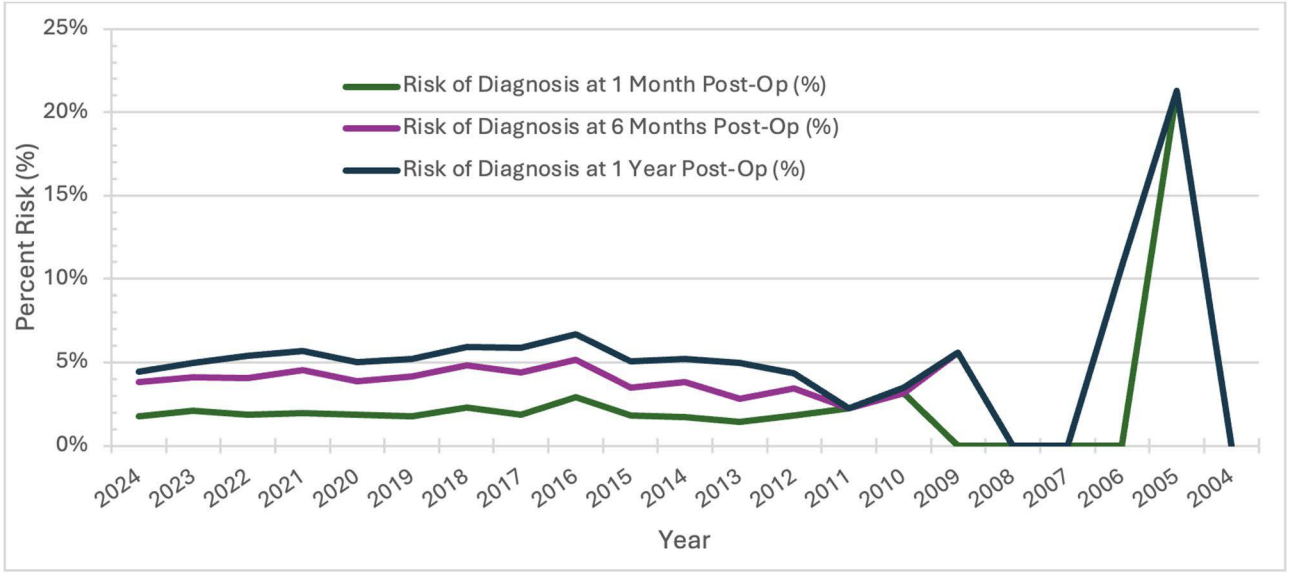

Fig. 4 Percent risk of first-time diagnosis of VDD in those 65 + at 1 month, 6 months, or 1 year after PFFR (2004–2024)

with femoral neck or peritrochanteric fractures had vitamin D levels below 20 ng/mL, indicating deficiency [21]. In elderly patients aged 65+, fragility fractures are known to increase all-cause mortality. The 1-year mortality rate for hip fracture patients ranges between 20 and 24%, with an increased mortality risk persisting beyond 5-years post-fracture [22]. An analysis by Campenfeldt et al. found that 55 out of 182 patients were deceased at a 10-year follow up after femoral neck fracture [23]. Further, after sustaining one fragility fracture, patients have an estimated 86% increased risk of sustaining an additional fracture without appropriate treatment for osteoporosis [24]. Therefore, it is important to not only screen for VDD and osteoporosis after osteoporotic fragility fractures, but to ensure appropriate treatment to reduce the risk of further fracture, and further mortality risk.

The number of fragility fractures overall in the United States are on the rise, with an estimated 2 million fractures each year [1]. One estimate predicts that in the year 2025 the total global number of hip fractures would reach 3.94 million and further increase to 6.26 million by 2050 [25]. The expected rise in fragility fractures suggests a greater demand for osteoporosis screening and

management in the future. The economic burden of osteoporotic fractures in the U.S. is already estimated at $57 billion annually and is expected to grow significantly. For example, while osteoporosis is typically treated pharmacologically with bisphosphonate therapy, specific brands of these medications have been shown to be more effective in reducing the incidence of various forms of fragility fractures, including Denosumab for reducing the occurrence of non-vertebral fractures, and Romosozumab and Ibandronate for preventing vertebral fractures and hip fractures, respectively [26]. However, annual expenses for branded oral bisphosphonates, one of the first-line treatments for osteoporosis, range from $12 [27]. Indeed, studies have demonstrated that bisphosphonate prescription rates have increased from 10 prescriptions per 1000 patients in 1998 to 120 prescriptions per 1000 patients in 2018, a 1200% increase in prescribing [6].

The underdiagnosis of osteoporosis has unfortunately been prevalent for decades as evidenced by similar studies to our own cohort. One such study published in 2017 demonstrated an increase in osteoporosis diagnoses from 13.2% before to 32.3% after injury, indicating a 19.1% increase in diagnoses of osteoporosis after hip fracture [28]. Another study published in 2007 described only 26.9% of 93 patients with fragility fractures as receiving a diagnosis of osteoporosis or osteopenia within 6 months post-fracture [29]. Unfortunately, this aligns with data indicating a lack of bone mineral density assessments in patients post-hip fracture. At 5-year follow up after low energy hip fracture, literature has demonstrated only an estimate of 11% of men and 27% of women as having undergone bone mineral density testing [30]. Previous studies have also documented the prevalence of VDD amongst elderly patients presenting with hip fractures. Carpintero et al. performed a prospective study in 109 elderly hip fracture patients to verify the relationship between vitamin D levels and functional recovery. In their study, 47.7% of all patients had vitamin D levels below laboratory reference values. Further, a statistically significant relationship was found between reduced vitamin D levels and poor functional recovery 1 year after the initial injury [31]. This underdiagnosis and undertreatment of osteoporosis has serious consequences, including increased risk of additional future fragility fracture and increased mortality after these injuries, which has been well described [32, 33].

The risk of first-time diagnosis of osteoporosis highlighted in our cohort was demonstrated to be only 9.80% at 1 year; only 5.16% of patients without preexisting diagnoses of VDD were captured at 2 years after PFFR. The percent risk of these first-time diagnoses remained relatively constant over time; however, the actual number of patients who received these first-time diagnoses did considerably increase during the study period, illustrating the growing burden of disease within our population. While the percentage of first-time diagnoses at 1 year suggest a paucity of appropriate screening in this at-risk population after PFFR, an encouraging finding in our analysis were in the trends of preexisting diagnoses of either osteoporosis or VDD prior to injury, increasing from 25 to 50% during our study period. While this may be partially reflective of the maturity of the data set available over time, this may indicate more appropriate screening prior to the sentinel event of a fragility fracture such as proximal femur fracture over time.

With fragility fractures becoming increasingly prevalent, the need for bone health specialists, including orthopedic surgeons, primary care providers, and endocrinologists, will continue to rise. Increased multidisciplinary collaboration can ensure comprehensive screening, early treatment, and prevention of future fractures. Prioritizing programs outlining the necessary components of this collaboration can improve osteoporosis management, reduce healthcare costs, and ultimately enhance the quality of life for aging individuals. One such program through the American Orthopedic Association (AOA) has demonstrated efficacy in closing the osteoporosis treatment gap. AOA's 'Own the Bone' program is a national post-fracture, systems-based, multidisciplinary fragility fracture preventative initiative, aiming to ultimately decrease the incidence of fragility fractures through a systems-based approach to osteoporosis treatment. Bone health treatment recommendations in this protocol include Calcium and Vitamin D supplementation, weight-bearing exercise, fall prevention education, smoking cessation, alcohol intake limitation, BMD testing, physician referral letters, and follow-up notes provided to the patient [10, 11]. Studies have shown improvement in post-fragility fracture osteoporosis care in sites throughout the United States participating in this and other similar initiatives. One study demonstrated that 53% of patients at 'Own the Bone' enrolled sites from 2010 to 2015 had BMD testing ordered and/or pharmacologic therapy for osteoporosis initiated after consultation [12]. This rate of osteoporosis management after hip fracture was higher than the 90th percentile of Healthcare Effectiveness Data and Information Set (HEDIS) measures implemented by Health Maintenance Organizations (HMOs) and Preferred Provider Organizations (PPOs) [12].

Limitations

This study has limitations to consider. This is a retrospective review, and therefore is subject to election, recall, and misclassification bias. As our patient population of interest was restricted to those recorded in the TriNetX database, inconsistencies in data entry and coding practices

which may differ amongst physicians and network-participating institutions could additionally lead to bias [34] as well as introducing the risk of bias from a data set that may not be complete, especially in the early years of the database before it reached maturity. While underscreening may partially explain the low rates of first-time diagnoses of osteoporosis and VDD at on year, under-coding could also contribute to these low rates. Our analysis is also limited to patients with proximal femur fractures, and underestimates rates and diagnoses of osteoporosis outside of patients treated for proximal femur fracture. The generalizability of our study to populations in other areas of the United States may be affected by use of this database, which predominately includes patient data from one geographic location. Prior studies have shown that VDD prevalence differs between femoral neck and peritrochanteric fractures, with a higher prevalence of VDD in the femoral neck fracture group [35]; our analysis focused more broadly, which may limit applicability of our study results to more specific populations. We were additionally unable to determine if formalized osteoporosis and/or vitamin D screening protocols were in place at the institutions from which the data was collected. Confirmatory clinical data was not available based on the design of this analysis. Length of follow up achieved by the included cohort was also not possible to consider for the same reason. Finally, our analysis was unable to determine the rate of these patients who received appropriate treatment for VDD or osteoporosis either before their injury, or after any first-time diagnosis post-injury.

Conclusion

The incidence of PFFR, and therefore the burden of screening for markers of bone health and subsequent treatment in at risk patients has increased over time. Rates of first-time diagnoses of osteoporosis or VDD after PFFR represent a current treatment burden of approximately 10% and 5% of this population at 1 year, respectively, with most first-time diagnoses of both conditions occurring within the first 6 months after injury. This number may underrepresent the true burden of disease, highlighting the necessity of screening protocols targeting this population. As the elderly population, and therefore the rate of PFFRs are expected to continue to increase, future studies should aim to implement protocols to help identify and address bone health in at risk patients at specific institutions, and to determine the efficacy of existing screening protocols in pairing patients with appropriate treatment for osteoporosis and VDD to avoid further complications.

Author contributions

EL, AW, and AY contributed to study conception and design. ZT and AY contributed to data collection. AY contributed to data analysis. AF contributed to initial manuscript draft. EL and AY contributed to final manuscript edits.

Funding

No funding was requested for this project.

Data availability

Research data is available via TriNetX.

Declarations

Competing interests

The authors declare no competing interests.

Conflict of interest

No conflicts of interest or disclosures were disclosed by the authors.

Ethics

This study is IRB approved through the University at Buffalo.

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