Osteoporosis Diagnosis: The Fragility Fracture Angle

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Abstract

Osteoporotic fragility fractures are emerging as a major public health issue and are associated with high rates of morbidity, mortality, and healthcare costs (Curtis, Moon, Harvey, & Cooper, 2017; Halldorsson et al., 2015). These types of fractures mostly impact older adult populations and can significantly diminish an individual's quality of life (Curtis et al., 2015; Halldorsson et al., 2015). The current state of the literature regarding identification and appropriate treatment of osteoporosis in the setting of fragility fracture is in a formative stage, one that raises many more questions than it answers, however a couple of trends are clear: consistently low rates of osteoporosis diagnosis and treatment in the setting of fragility fracture/s, and a consistent lack of formalized assessment/treatment protocols.

Oregon Health and Science University (OHSU) Hospital, in Portland, Oregon, serves a large older adult population and established a formalized guideline for the diagnosis, assessment, and treatment of osteoporosis in the setting of fragility fracture March 2018. The following project examined OHSU's adherence to the established protocol as a first step in a quality improvement initiative with the goals of increasing identification and treatment of osteoporosis via the presence of fragility fracture and, in turn, decreasing the high rates of morbidity, mortality, and healthcare cost associated with this condition.

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Introduction: The Clinical Problem

Osteoporotic fragility fracture rates have been steadily increasing as the population ages and are gaining recognition as a major public health issue. Globally, fragility fractures now contribute significantly to overall rates of morbidity, mortality, and healthcare spending, and have a significantly negative, if not devastating, impact on an individual's quality of life (Curtis, Moon, Harvey, & Cooper, 2017; Halldorsson et al., 2015). In the United States, the National Osteoporosis Foundation (NOF) estimates two million fragility fractures occur annually, and that number is associated with an estimated $19 billion in healthcare costs (Halldorsson et al., 2015). These numbers are expected to rise to three million and $25.3 billion, respectively, by the year 2025 and, to add further perspective, it is estimated that approximately one in two women and one in four men will experience a fragility fracture in their lifetime (Halldorsson et al., 2015; NOF, 2018).

Fragility fractures are defined as low-impact fractures of the proximal humerus, distal radius, proximal femur, and compression fractures of the thoracic/lumbar vertebrae (Curtis et al., 2017; Takayuki, 2017). Fragility fractures result from a fall of standing height or less and are often the first clinical sign of osteoporosis (Dang, Zetumer, & Zhang, 2019; Takayuki, 2017). Vertebral fractures are the most common, but proximal femur fractures have the worst outcome of all fragility fracture types, with 24.5-36% mortality noted within the first year following fracture (Rolvien & Amling, 2016). The American Academy of Orthopaedic Surgeons (AAOS) notes that fragility fractures increase the risk of a future fracture (which begets increased disability, morbidity, mortality, and healthcare costs) and that treatment of patients with these

fractures can reduce future fracture risk by up to 50%, yet the majority of patients do not receive treatment (2016).

As fragility fracture is often the presenting sign of osteoporosis and stratifies a patient at higher risk for future fracture and poor outcomes, inpatient providers have a unique opportunity to intervene via the assessment, diagnosis, and treatment of osteoporosis, an opportunity that could result in the reduction of disease progression, additional disability, and healthcare spending. The AAOS, American Orthopaedic Association (AOA), Orthopaedic Trauma Association (OTA), and International Geriatric Fracture Society (IGFS) released a position statement in 2016 that called for healthcare providers to better manage patients with fragility fractures, including treatment and secondary prevention strategies, by way of best practice development and data dissemination. The position statement did not include many specific recommendations, although that may be attributable to the fact that this area of research is currently evolving.

Literature Review

There is little consensus in the available literature regarding appropriate treatment of osteoporosis following a fragility fracture. The only constants throughout available studies are the focus on older populations, the low rates of treatment, even in cases where an osteoporotic fragility fracture is diagnosed, and the significant morbidity, mortality, and financial burden of the underdiagnosis and treatment of this condition. It is therefore important to examine findings for applicability to each specific practice setting.

In 2018, Daniel et al. published a single-center cohort study that examined the number of patients under anti-osteoporotic treatment (OT) at the time of hip fragility fracture (HF), and the number receiving treatment at one- and four-years following HF, versus the number of patients

who should have been receiving OT based on the current Portuguese Cost-effectiveness Recommendations (PCER) and FRAX assessment, a validated osteoporosis risk assessment tool that estimates 10-year risk of fracture and guides treatment decisions (Daniel et al., 2018; NOF, 2019). Daniel et al. found two only two significant associations between demographic data and OT, a negative association between comorbidity score (CCI) and OT prescription prior to HF ($p=0.011$), and a positive association between ADL independence score (KI) and OT prescription prior to HF ($p=0.003$); which suggests that individuals with more comorbidities were less likely to receive OT, and individuals with higher functional status were more likely to receive OT (2018).

In 2017, Keshishian et al. published a large retrospective, observational cohort study that used U.S. administrative claims data from the national Medicare database to evaluate for predictors of osteoporosis medication use and compare the risk of recurrent fragility fracture within one year of initial fragility fracture presentation (index event) between treated and untreated women. Overall, 8.3% of participants had a subsequent fragility fracture within 12 months of the index event (Keshishian et al., 2017). Statistical analysis revealed that treated women had a significantly lower risk of fracture compared to untreated women (6.4% vs. 9%, $p<0.001$), untreated women experienced subsequent fracture much sooner than treated women (165.2 +/- 109.4 days vs. 216.2 +/- 95.3 days, $p<0.001$), and untreated women accounted for a higher proportion of subsequent hip/pelvis/femur fractures (59.1% vs. 51.5%, $p<0.001$) (Keshishian et al., 2017).

Multivariate analyses further revealed that women diagnosed with dementia (HR 0.92, 95% CI: 0.89-0.96) and black women (HR 0.92, 95% CI: 0.85-1.00) were significantly less likely to be prescribed osteoporosis treatment following index fracture, that the strongest predictor for treatment following index fracture was treatment already initiated at baseline (HR 7.87, 95% CI:

7.67-8.07), and that treatment within the 12 months following index fracture lowered the risk of subsequent fractures by 21% (HR =0.79, 95% CI: 0.75-0.83), compared to non-treatment (Keshishian et al., 2017).

In 2019, Dang et al. published a large cross-sectional cohort study that used the Medicare Standard Analytic Files (SAF) database to analyze rates, locations, and characteristics of recurrent fragility fractures in U.S. Medicare Part A/B patients >64 years old. The majority of index fractures (35%) were hip fractures; at 12-month follow up 5.8% of patients experienced a subsequent fragility fracture, at 24-month follow up that number rose to 8.8%, and at 36-month follow up that number reached 11.3% (Dang et al., 2019).

Of all index fracture types, vertebral compression and proximal humerus fractures were associated with higher incidence of subsequent fragility fracture within 36 months (13.8% and 13.2% respectively, $p< 0.001$) (Dang et al., 2019). At 36-month follow up, hip fractures comprised the majority of subsequent fragility fractures (57.5%, $p<0.001$), regardless of index fracture type, with the exception of ankle index fracture (Dang et al., 2019). Initial hip fracture was associated with a significantly higher all-cause mortality rate at 12-month follow up (21.3%), followed by vertebral compression fracture (14.7%), and proximal humerus fracture (11.0%) ($p<0.001$) (Dang et al., 2019).

In 2018, Van Geel et al. published a prospective cohort study that analyzed the effect of the initiation of bisphosphonate therapy, in addition to calcium and vitamin D supplementation, following osteoporotic fracture, on the risk of mortality and subsequent fracture. Data analysis found that the majority of the cohort had either osteoporosis (45.5%) or osteopenia (42.0%), and that bisphosphonate initiation was indicated/recommended for just about half of the study population (50.6%).

Patients recommended bisphosphonate therapy had a higher absolute subsequent fracture risk (13.3 vs. 11.8%) but after adjusting for their baseline high-risk profile, the calculations for subsequent fracture hazard risk were significantly lower than that of the non-bisphosphonate faction of the cohort (HR: 0.60, 95% CI: 0.49-0.73, $p<0.001$) (Van Geel et al., 2018). Similarly, the absolute mortality risk was (as expected) higher in the bisphosphonate therapy group (15.0 vs. 9.5%), but after adjusting for the baseline high-risk profile, the calculations for mortality hazard risk were significantly lower than that of the non-bisphosphonate faction of the cohort (HR: 0.79, 95% CI: 0.64-0.97, $p=0.021$) (Van Geel et al., 2018).

Van Geel et al.'s 2018 study has a number of limitations, from its lack of detailed methodology to its questionable statistical analysis however, it does pose the possibility that early bisphosphonate initiation could reduce the risks of subsequent fracture and mortality. Daniel et al.'s 2018 study was limited by the small size and reliance on self- or caregiver-reported data. Keshishian et al.'s 2017 and Dang et al.'s 2019 studies were much larger but relied on administrative coding for all of their analysis, which may have skewed the results.

Project Purpose

The project detailed below examined the assessment, diagnosis, and treatment of osteoporosis in the setting of fragility fracture/s at Oregon Health and Science University Hospital against the best practice guideline that went into effect March 1, 2018. The project goal was to quantify actual rates of guideline adherence against expected rates as a first step in an ongoing quality improvement effort to increase the identification and treatment of osteoporosis via the presence of fragility fracture and, in turn, decrease the high rates of morbidity, mortality, healthcare cost, and reduced quality of life associated with this condition. The project was informed by the

strengths and weaknesses of available research studies, and the knowledge that inpatient providers are uniquely situated to intervene in this emerging public health issue.

OHSU's "Guideline for Osteoporosis Diagnosis, Evaluation, and Appropriate Evidence-Based Treatment in the Setting of a Fragility Fracture(s) for All Hospitalized Adults" calls on providers to recognize that certain fractures incurred from low-impact trauma are diagnostic of osteoporosis and directs providers to 1) diagnose a fragility or pathologic fracture if it is a fracture of the proximal humerus, distal radius, proximal femur, or compression fractures of the thoracic or lumbar vertebrae, and occurred from a fall from standing height or less, 2) diagnose osteoporosis in this setting, and 3) complete the required osteoporosis evaluation, screening, and treatment protocol (2018).

The OHSU protocol consists of a review of prior-to-admission (PTA) medications to assess for possible high-risk medications that may be discontinued or dose-adjusted, screenings for malnutrition and chronic alcohol use, a fall risk assessment, a physical therapy evaluation, a serum vitamin D level, and prescriptions for a vitamin D supplement, calcium supplement, and/or bisphosphonate therapy, if indicated (2018).

Methods

Setting

OHSU Hospital, a 562-bed facility that is the only academic level one trauma center in the state of Oregon and serves approximately 2,900 patients per year (OHSU, 2017). Approximately 60% of the trauma population at OHSU are brought directly to the hospital from the scene of injury, and approximately 40% are transferred to OHSU from a referring facility for a higher level of care (OHSU, 2017).

Population

Admitted patients (any unit) between March 1, 2018-December 31, 2019, age >50 years at time of hospital admission, with a diagnosis of proximal humerus fracture, distal radius fracture, proximal femur fracture, or compression fracture/s of the thoracic and/or lumbar vertebrae in the setting of a low-impact trauma (fall from standing height or less). Patients were only excluded if they fell outside of the inclusion parameters.

Data Collection

Retrospective electronic medical record (EMR) chart review via OHSU's Epic software system. A report was generated from Epic to identify all patients who met inclusion criteria. The report specified each individual patient's encounter date, admission status (inpatient), age, gender, mechanism of injury, and fracture diagnosis. Individual patient charts were reviewed to ensure inclusion criteria was met at the time of the identified encounter (hospitalization); all patient encounters reviewed were included in the project cohort (n=72). Individual patient encounters were then reviewed for compliance with OHSU's "Guideline for Osteoporosis Diagnosis, Evaluation, and Appropriate Evidence-Based Treatment in the Setting of a Fragility Fracture(s) for All Hospitalized Adults" and demographic data collection.

Measures

Data was located in various parts of the patient medical record, including various encounter notes (See Appendix A). Data variables collected were primarily binary measurements in order to assess adherence with established protocol. Categorical or continuous data collected included demographic information, primary treatment team, and length of stay (See Appendix A).

Data Analysis

Binary data were analyzed by protocol item as percentage of patient encounters that met diagnosis, assessment, and treatment guidelines over total cohort encounters. Categorical data were tallied and analyzed as percentages of particular response over total responses. Continuous data were quantified by minimum, maximum, and average calculations.

Ethical Considerations

OHSU's Institutional Review Board (IRB) approved the project prior to data collection commencement. Patient charts were only accessed/reviewed for data pertinent to the project. The report generated from Epic and the data collection spreadsheet were stored in, and accessed from, OHSU's secure Box site. All patient information was de-identified and assigned a numerical code to ensure Protected Health Information (PHI) remained safe. The Epic report and data collection spreadsheet were both destroyed (deleted) after data analysis was concluded.

Results

Seventy-two patients were identified from the original Epic report, all of which were confirmed to have sustained a fracture in the setting of a low-impact trauma that would qualify as a fragility or pathologic fracture diagnostic of osteoporosis, and thus all were included in final project cohort (n=72). Individuals ranged in age from 50-101 years, with an average age of 78.65 years (See Appendix B). Hospital length of stay ranged from 1-69 days, with an average of 6.39 days (See Appendix B). No diagnoses of fragility or pathologic fracture were made for any member of the cohort and only 11% were diagnosed with osteoporosis (See Appendix B). Significantly, of those diagnosed with osteoporosis, 67% had a previous diagnosis of osteoporosis that was carried forward into the fragility fracture encounter (See Appendix B).

The trauma service was the primary treatment team for the majority of patients (79.2%), although the hospitalist (15.3%) and emergency department services (5.5%) also cared for patients in the project cohort (See Appendix B). Approximately two thirds (66.7%) of the patients who were diagnosed with osteoporosis were trauma service patients but, as this service was the primary treatment team for most of the patient encounters, and only approximately one tenth of the total cohort (11.1%) carried the diagnosis, these findings are likely of no associative value (See Appendix B).

A majority of patients were female (68%), white non-Hispanic (90%), and listed English as their primary language (See Appendix B). Uncomplicated ground-level falls were the most common fall type (62.5%), and proximal femur fractures (41.67%), followed by thoracic/lumbar vertebrae compression fractures (21.43%) were the most common fracture types (See Appendix B). Although the rates of fragility/pathological fracture and osteoporosis diagnoses were abysmal, parts of the osteoporosis assessment and treatment protocols were implemented consistently.

99.4% of cohort encounters had PTA medication assessments completed, 91.7% had formal physical therapy evaluations, 89.5% had a chronic alcohol use screening completed, 73.6% had nutrition assessments completed, 70.8% had serum vitamin D levels checked, and almost half of the cohort (48.61%) were prescribed some form of medication treatment (See Appendix C). Of those patients who did not receive a medication treatment, providers recorded a reason for the deferral of treatment in 14.3%; the main reason given (80.0%) was due to the patient being transitioned to comfort or hospice care measures (See Appendix C). Serum vitamin D levels for those tested were mostly low (58.8%) or within defined limits (41.2%), and vitamin D supplements were initiated (41.7%), continued at home dose (5.6%), or increased

from home dose (1.4%) for approximately half of the cohort (48.7%) (See Appendix C). Calcium supplements were initiated (23.6%), continued at home dose (5.6%), or increased from home dose (1.4%) for approximately a third (30.6%) of the cohort (See Appendix C). Bisphosphonate therapy was either initiated (6.9%) or continued at home dose (4.2%) for approximately a tenth (11.1%) of the cohort (See Appendix C).

The fact that no diagnoses of fragility or pathologic fracture were made coupled with the low rate of osteoporosis diagnoses suggests that the higher rates of adherence to the assessment and screening portions of the guideline protocol were likely due to the fact that these items are also a part of numerous trauma injury guidelines, although no causal relationship can be asserted in a retrospective study. The higher rates of vitamin D supplement prescription may be attributed to the frequency of serum vitamin D assessment, and the low rates of bisphosphonate prescription may be due to lack of osteoporosis identification versus contraindication or side effect profile in the older adult population but, again, no causal relationship can be asserted.

Project Limitations

The retrospective study design limited the amount of data readily accessible and made it necessary to mine for data in various locations in the patient encounter record. The design also allowed for the possibility of bias and multiple confounding variables, which precluded the identification of cause-and-effect relationships, and therefore limited the utility of project results to a first step in additional hypotheses generation.

The Epic report created to define the project cohort was meant to be supplemented by additional reports that would identify demographic, diagnosis code, and payer data but access to the Epic staff who could assist with running such reports became nonexistent during the corona virus pandemic that began in winter 2020. Fortunately, the retrospective project design allowed

for access to some, but not all, demographic and diagnosis code data, although payer data was inaccessible through student permissions. University restrictions in light of the pandemic prohibited access to on-campus networked computers, making it essential to conduct chart review via remote access. Unfortunately, this created a much more labor intensive and time-consuming chart review process, owing to issues with internet lag speeds and small computer monitor size.

While the inefficiencies in data collection unique to this period in history increased the time required to complete data collection and resulted in a loss in payer data, the main data points necessary for protocol adherence analysis were able to be recorded. Access to a statistician was lost to the pandemic, resulting in the need for independent investigation into the most relevant statistical analyses for a retrospective project. The project data examined was predominantly binary and was analyzed by adherence percentage calculations against OHSU guidelines. The limited evidence-based practice research and lac of standards for osteoporosis diagnosis, assessment, and treatment in the setting of fragility fractures meant that the project was confined to a single-center study, although the themes noted in the project did echo those found in the available literature.

Practice Implications

The original hypothesis of the project was that OHSU would have low rates of osteoporosis diagnoses and treatment in the setting of fragility/pathologic fractures, even with an established guideline. The hypothesis was based on the trend of low rates of diagnoses and treatment noted in the available literature, and the result was as suspected, although the specific reasons why individual facets of the OHSU guideline had disparate rates of adherence remains unclear.

In the retrospective analysis, there was no way to ascertain if the OHSU guidelines were referenced by or known to the providers. The lack of fragility/pathological fracture diagnoses and low rate of osteoporosis diagnoses suggest that providers rarely made the connection between the types of fractures that are diagnostic of osteoporosis in the setting of a low-impact trauma. However, the project collected data in the first twenty-one months following the OHSU guideline roll-out, and communication around protocol updates is often unclear and culture change often slow, which may have been factors in the lack of guideline adherence.

The project cohort was comprised of trauma patients, a faction of hospitalized individuals who frequently require medication and alcohol/substance use screenings, nutrition assessments and interventions to promote healing, and physical therapy to assist with mobility recovery. The inherent assessment and intervention needs of the trauma population likely contributed to the high rates of adherence to the assessment and screening protocol items of the guideline, the overlap ultimately beneficial to the fragility fracture population.

Additional research into the reasons for such low rates of osteoporosis diagnosis and treatment in the fragility fracture population are necessary to improve the care these individuals receive. A good next step would be for the university hospital to conduct a study to assess provider knowledge of fragility fractures as diagnostic of osteoporosis, provider awareness of and attitudes toward the OHSU guideline, and provider documentation practices, including the Epic system's ease of use. It is possible that interventions geared toward improved provider education and awareness, and standard documentation practices would result in improved outcomes for this high-risk population.

Conclusion

Fragility fractures are on the rise worldwide and considered an emerging major public health issue, yet providers do not appear to recognize these types of fractures, nor identify them as diagnostic of osteoporosis. OHSU is one of few institutions that has a guideline for osteoporosis diagnosis, evaluation, and treatment in the setting of a fragility fracture but, consistent with global trends, has extremely low rates of diagnosis and treatment of these conditions. OHSU inpatient providers have an opportunity to improve their care of this population via improved adherence with the current guideline, and early intervention is associated with a reduction of disease progression and/or additional disability, a reduction in unnecessary healthcare spending, and improvement in or maintenance of each individual's quality of life.

References

American Academy of Orthopaedic Surgeons. (2016). Position statement: Orthopaedic care of patients with fragility fractures. Retrieved from https://www.aaos.org/uploadedFiles/PreProduction/About/Opinion_Statements/position/Position%20Statement-%20Orthopaedic%20Care%20of%20Patients%20with%20Fragility%20Fracture%20-%20Final%20Verision.pdf

Curtis, E. M., Moon, R. J., Harvey, N. C., & Cooper, C. (2017). The impact of fragility fracture and approaches to osteoporosis risk worldwide. *Bone, 104*, 29-38. doi:10.1016/j.bone.2017.01.024

Dang, D. Y., Zetumer, S., & Zhang, A. L. (2019). Recurrent fragility fractures: A cross-sectional analysis. *Journal of the American Academy of Orthopaedic Surgeons, 27*(2), E85-E91. doi:10.5435/JAAOS-D-17-00103

Daniel, A., Marques, M. L., Brites, L., Torres, C., Marques, A., & Pereira Da Silva, J. A. (2018). Adherence to the recommended prevention strategies before and after a hip fragility fracture: What makes us go blind? *Acta Reumatológica Portuguesa, 2018*(2), 93-101. Retrieved from http://www.actareumatologica.com/files/article/1205_adherence_to_the_recommended_prevention_strategies_before_and_after_a_hip_fragility_fracture_what_makes_us_go_blind__file.pdf

Halldorsson, B. V., Bjornsson, A. H., Gudmundsson, H. T., Birgisson, E. O., Ludviksson, B. R., & Gudbjornsson, B. (2015). A clinical decision support system for the diagnosis, fracture

risks, and treatment of osteoporosis. *Computational and Mathematical Methods in Medicine, 2015*, 7. doi: 10.1155/2015/189769

Keshishian, A., Boytsov, N., Burge, R., Krohn, K., Lombard, L., Zhang, X. . . Baser, O. (2017). Examining the treatment gap and risk of subsequent fractures among females with a fragility fracture in the US Medicare population. *Osteoporosis International, 28*(8), 2485-2494. doi:10.1007/s00198-017-4072-6

Majumdar, S. R., Lier, D. A., Hanley, D. A., Juby, A. G., & Beaupre, L. A. (2017). Economic evaluation of a population-based osteoporosis intervention for outpatients with non-traumatic non-hip fractures: The "catch a break" 1i [type C] FLS. *Osteoporosis International, 28*(6), 1965-1977. doi:10.1007/s00198-017-3986-3

National Osteoporosis Foundation. (2018). About NOF. Retrieved from https://www.nof.org/about-us/about-nof/

National Osteoporosis Foundation. (2019). Risk assessment: FRAX. Retrieved from https://www.nof.org/patients/diagnosis-information/risk-assessment-frax/

Oregon Health and Science University. (2017). Trauma center annual report. Retrieved from https://www.ohsu.edu/trauma-center/trauma-center-annual-report

Oregon Health and Science University. (2018). Guideline for osteoporosis diagnosis, evaluation, and appropriate evidence-based treatment in the setting of a fragility fracture(s) for all hospitalized adults. Office of Clinical Integration and Evidence Based Practice.

Rolvien, T., & Amling, M. (2016). *Bone biology in the elderly: Clinical importance for fracture treatment. Innovative Surgical Sciences, 1*(2). doi:10.1515/iss-2016-0025

Takayuki, T. 2017. Epidemiology of fragility fractures and fall prevention in the elderly: A systematic review of the literature. *Current Orthopaedic Practice, 28*(6), 580-585. doi:10.1097/BCO.0000000000000563

Van Geel, T. A., Bliuc, D., Geusens, P. P., Center, J. R., Dinant, G., Tran, T. . . . Eisman, J. A. (2018). Reduced mortality and subsequent fracture risk associated with oral bisphosphonate recommendation in a fracture liaison service setting: A prospective cohort study. *PLoS ONE, 13*(6). doi:10.1371/journal.pone.0198006

Appendix A

Table 1

Data measurements

Data Point	Data Type	Location of Data in Epic Record
Demographic Data		
Age	Continuous	Demographics list
Sex	Categorical	Demographics list
Race	Categorical	Demographics list
Primary language	Categorical	Demographics list
Primary Treatment Team	Categorical	Encounter list, progress note, discharge note
Hospital Length of Stay	Continuous	Encounter list, discharge note
Readmission for pathological/fragility fracture	Binary Y/N	Encounter list, Problem list, progress note, discharge note
Length of time between pathological/fragility fracture readmission and original admission	Continuous	Encounter list, Problem list, progress note, discharge note
Patient died during pathological/fragility fracture admission	Binary Y/N	Encounter list, progress note, discharge note
Protocol Compliance Data		
Diagnosis of "pathological" or "fragility" fracture	Binary Y/N	Problem list, progress note, discharge note
Diagnosis of "osteoporosis"	Binary Y/N	Problem list, progress note, discharge note
Prior to admission (PTA) medications reviewed	Binary Y/N	PTA Medication list, progress note, discharge note
Malnutrition screening completed	Binary Y/N	Progress note, discharge note, dietician note
Chronic alcohol use screening completed	Binary Y/N	Progress note, discharge note, social work note
Fall risk assessment completed	Binary Y/N	Progress note, discharge note, physical therapy note
Physical therapy assessment completed	Binary Y/N	Physical therapy note
Serum vitamin D lab completed	Binary Y/N	Lab list
Result of serum vitamin D lab, if ordered	Binary Y/N	Lab list
Osteoporosis treatment started	Binary Y/N	Progress note, discharge note
If osteoporosis treatment was not started, was reason given	Binary Y/N	Progress note, discharge note
Specific reason for not starting treatment	Binary Y/N	Progress note, discharge note
Calcium supplement prescribed	Binary Y/N	Medication list, progress note, discharge note
Vitamin D supplement prescribed	Binary Y/N	Medication list, progress note, discharge note
Bisphosphonate medication prescribed	Binary Y/N	Medication list, progress note, discharge note

Appendix B

Table 2

Cohort overview

Sample Data (n=72)	Number	Percentage
Patient Demographics		
Age:		
Min	50.2	
Max	101.2	
Average	78.65	
Gender:		
Male	23	31.94%
Female	49	68.06%
Race:		
White Non-Hispanic	65	90.28%
Asian	4	5.56%
Unknown	2	2.78%
American Indian	1	1.39%
Language:		
English	70	97.22%
Korean	1	1.39%
Hindi	1	1.39%
Hospitalization		
Primary Treatment Team:		
Trauma	57	79.17%
Hospitalist	11	15.28%
ED	4	5.56%
Length of Stay:		
Min	1	
Max	69	
Average	6.39	
Readmitted Patient:		
Yes	0	
No	72	
Deceased Patient:		
Yes	2	2.78%
No	70	97.22%
Mechanism of Injury		
Fall from bed	5	6.94%
Fall from chair	1	1.39%
Fall from non-moving wheelchair	2	2.78%
Fall on same level from slipping, tripping, and stumbling WITH striking against other object	12	16.67%
Fall on same level from slipping, tripping, and stumbling WITHOUT striking against other object	45	62.50%
Unspecified	7	9.72%
Osteoporotic Fracture Type by Mechanism of Injury		
Proximal humerus fracture	22	26.19%
Distal radius fracture	9	10.71%
Proximal femur fracture	35	41.67%
Compression fracture of thoracic or lumbar vertebrae	18	21.43%
Compression fracture of thoracic vertebrae	14	16.67%
Compression fracture of lumbar vertebrae	4	4.76%
Diagnoses		
Fragility or Pathologic Fracture Diagnosed:		
Yes	0	0.00%
No	72	100.00%
Osteoporosis Diagnosed:		
Yes	8	11.11%
No	60	83.33%
PMH	4	5.56%

Appendix C

Table 3

Protocol adherence

Sample Data (n=72)	Number	Percentage
Osteoporotic Fragility Fracture Guideline Adherence		
Osteoporosis Medication/s Perscribed:		
Yes	35	48.61%
No	37	51.39%
If no medications perscribed, was a reason given:		
Yes	5	13.16%
No	33	86.84%
Stated reason for no medications:		
Hospice Patient	2	40.00%
Comfort Care Patient	2	40.00%
Stage 3 CKD	1	20.00%
Calcium Supplement Perscribed:		
Yes (new)	17	23.61%
No	50	69.44%
Prior to admission medication continued	4	5.56%
Prior to admission medication increased	1	1.39%
Vitamin D Supplement Perscribed:		
Yes (new)	30	41.67%
No	37	51.39%
Prior to admission medication continued	4	5.56%
Prior to admission medication increased	1	1.39%
Bisphosphonate Perscribed:		
Yes (new)	5	6.94%
No	64	88.89%
Prior to admission medication continued	3	4.17%
Prior to admission medication increased	0	0.00%
Serum Vitamin D Completed:		
Yes	51	70.83%
No	21	29.17%
Serum Vitamin D Result:		
High	0	0.00%
Low	30	58.82%
Within defined limits	21	41.18%
DXA Scan Referral Made:		
Yes	1	1.39%
No	71	98.61%
Prior to Admission Medication Screen Complete:		
Yes	68	94.44%
No	4	5.56%
Physical Therapy:		
Yes	66	91.67%
No	6	8.33%
Nutrition Assessment Completed:		
Yes	53	73.61%
No	19	26.39%
Alcohol Assessment Completed:		
Yes	9	12.50%
No	63	87.50%