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Validation of Diagnostic Codes for Subtrochanteric, Diaphyseal, and Atypical Femoral Fractures Using Administrative Claims Data

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Abstract

Purpose—Administrative claims databases have large samples and high generalizability. They have been used to evaluate associations of atypical subtrochanteric fractures with bisphosphonates. We developed and assessed accuracy of claims-based algorithms with hospital and physician diagnosis codes for these fractures.

Methods—Medical records and radiology reports of all adults admitted at University of Alabama at Birmingham Hospital from 2004-2008 with ICD-9 hospital discharges and surgeons' fracture repair codes for subtrochanteric femoral fractures, and random sample of other femoral fractures were reviewed. An expert panel adjudicated any discordance.

Results—We identified 137 persons with suspected subtrochanteric femoral fractures and randomly selected 50 persons with either suspected diaphyseal femoral fractures or hip fractures other than subtrochanteric and diaphyseal femoral fracture (typical hip fracture). Eleven patients had radiographic features indicative of atypical femoral fractures. The positive predictive value (PPV) of claims-based algorithms varied with primary or secondary positions on discharge diagnoses, and the sources of diagnosis codes. The PPV for fractures ranged 69-89% for subtrochanteric femoral, 89-98% for diaphyseal femoral and 85-98% for typical hip fractures. The PPV of administrative codes for defining a femoral fracture as atypical was low and imprecise.

Conclusions—Claims-based algorithms combining hospital discharges with surgeon's diagnosis codes had high PPV to identify the site of subtrochanteric or diaphyseal femoral fractures versus typical hip fractures. However, claims-based data were not accurate in identifying atypical femoral fractures. These claims algorithms will be useful in future population-based observational studies to evaluate associations between osteoporosis medications and subtrochanteric and diaphyseal femoral fractures.

Keywords

Atypical femoral fracture; Diagnostic Codes; Administrative Claims Data

Introduction

Bisphosphonates remain the first-line therapy for the majority of patients with osteoporosis [1]. These drugs increase bone mineral density, reduce biochemical markers of bone turnover, and decrease the number of osteoporotic fractures at both vertebral and non-vertebral sites [2-13]. An increasing number of reports suggest association between bisphosphonates use and fractures of the subtrochanteric and proximal diaphyseal regions of the femur after minimal or no trauma. The occurrences of these fractures with minimal trauma, their uncommon anatomical position and the other unusual radiographic features of these fractures have helped coin the term “atypical femoral fractures”. Multiple case reports and small case series have raised concern about a possible association of such fractures with long term bisphosphonates use [14-22]. On the other hand, a registry-based cohort study in Denmark that used administrative data showed no difference in the incidence rate of hip and subtrochanteric / diaphyseal femur fractures between alendronate users and a matched comparison group [23]. Secondary analyses using results of three large, randomized bisphosphonate trials also demonstrated very rare occurrences of subtrochanteric or diaphyseal femoral fractures and showed no significantly increased risk even among women who were treated with bisphosphonates for nearly 10 years [24]. Recently, a population-based, nested case-control study in Canada, also relying on administrative data, demonstrated an association between long-term bisphosphonate use and subtrochanteric or femoral shaft fractures [25].

Because of cost, feasibility and generalizability concerns of conducting long-term safety studies using randomized controlled trials, large observational studies are commonly utilized to clarify these associations. Administrative claims databases often provide a unique population-base useful for such studies. However, the accuracy of administrative claims to identify certain fracture types is not well established. While administrative claims data have been used to define some common types of fractures [26-29] as well as those with radiographic features considered atypical [17,20,30], to our knowledge, few studies have assessed the positive predictive value (PPV) of subtrochanteric and diaphyseal femoral fracture codes. Ray et al reported a PPV of 75% for the diaphyseal femoral fracture ICD-9 (International Classification of Diseases, Ninth Revision, Clinical Modification) code [31]. In contrast, Spangler et al recently reported PPV for the various diaphyseal femoral fracture ICD-9 sub-codes that ranged from 20-83% and a PPV of 50% for subtrochanteric femoral fracture ICD-9 code [32]. In another cohort of women aged 68 years or older ICD-10 codes had a 90% PPV (95% CI 88-92) for patients hospitalized with a subtrochanteric and diaphyseal femoral fractures. In order to develop and validate claims-based algorithms for identification of subtrochanteric and diaphyseal femoral fractures, hip fractures other than subtrochanteric and diaphyseal femoral fracture (typical hip fractures) and atypical femoral fractures, we assessed the accuracy of hospital and physician diagnosis codes to identify these fractures.

Methods

Study Design and Data Sources

We used institutional data from the University of Alabama at Birmingham Health System (UABHS) to identify patients suspected of having a femoral fracture on the basis of inpatient or outpatient diagnosis codes (ICD-9). It was essential to include outpatient codes because surgeons' diagnosis codes and fracture repair records appear only in outpatient files, not in hospital billing records. For each suspected femoral fracture, medical records and radiology reports were obtained and used as the referent standard to classify the type of femoral fracture. We assessed the diagnostic properties of algorithms based on ICD-9 diagnosis codes appearing on hospital discharge and surgeons' fracture repair records to identify a closed subtrochanteric or closed diaphyseal femoral fractures, or typical closed hip fracture.

Eligibility and Identification of Suspected Femoral Fractures

Candidates for study inclusion were all patients with an ICD-9 diagnosis code for femoral fracture on their hospital discharge summary diagnosis list; these candidates were defined as having suspected fractures. The ICD-9 codes used for selection are listed in Appendix 1. We identified 2,133 patients admitted to UAB hospital and having a discharge diagnosis of femoral fracture from January 1, 2004 to December 31, 2008. Individuals with hospital discharge diagnosis for open femoral fracture and distal end femoral fractures were excluded because these fractures are usually caused by major trauma and not associated with longer term bisphosphonates use (Appendix 1). Consistent with available resources to perform medical record reviews, we selected a total of 235 patients for validation, including all patients with suspected subtrochanteric femoral fracture (n=137) and random samples of patients with diaphyseal femoral fracture (n=50), and hip fracture other than subtrochanteric and diaphyseal femoral fractures (typical hip fracture) (n=50) (Figure 1). Of note, a sample size of 50 is required to generate an error of $\pm 10\%$ at a 95% confidence interval, given an estimated PPV of 85%.

Radiology and Medical Record Reviews

After identifying patients suspected to have a closed femoral fracture using the administrative data, radiology and medical records were independently reviewed by two trained physician reviewers (AJ, PN, NP, and BS) as the "gold standard". Femoral fractures were confirmed and classified according to subtype of femoral fractures by this expert group. Based on the clinical history, radiology report, operative note, and discharge summary accounting for the index admission, patients were assigned to one of the following classifications: (1) subtrochanteric femoral fracture, defined as fracture at the region between the lesser trochanter and a point 5 centimeters distal; (2) diaphyseal femoral fracture, defined as fracture at the region between subtrochanteric and supracondylar areas; or (3) "typical" hip fracture, other than subtrochanteric and diaphyseal femoral fracture. We also abstracted the medical records information on circumstances under which the fracture occurred and underlying disorders that compromised the integrity or strength of the skeletal system. The timing of confirmed femoral fractures was further classified as incident, prevalent, or unable to determine. A radiologists' assessment of the acuity of the fracture in

the written radiology report was used as the gold standard to classify the timing of femoral fractures. When the fracture onset was not specifically mentioned by the radiologist, physician notes that documented a new femoral fracture in conjunction with confirmed femoral fracture on an imaging test also satisfied the definition of an incident fracture.

The kappa statistics of inter-reviewer agreement for the diagnosis of subtrochanteric and diaphyseal femoral fracture were 0.98 and 0.83, respectively. Discordance between radiology report, operative note, and discharge summary diagnosis, or disagreement between reviewers, were adjudicated by an expert panel comprised of 3 radiologists (PL, RL, and MP), 2 rheumatologists (KS and JC), and 1 orthopedist (DV).

To discern radiographic patterns that have been proposed to define the ‘atypical’ features of these fractures, two reviewers, blinded to administrative data, (a radiologist (RL) and a physician (NP)) further assessed the radiographs of the study patients. Features they evaluated were: simple, transverse, or short oblique fracture with focal and substantial cortical thickening especially of the lateral cortex where the fracture process initiated that may produce an appearance of cortical “beaking” or “flaring” adjacent to the discrete fracture line. These criteria were similar to the 5 ‘major’ criteria defined by the American Society for Bone and Mineral Research (ASBMR) for designating a femoral fracture as atypical (1-location anywhere along the femur from just distal to lesser trochanter to just proximal to supracondylar flare; 2-associated with no or minimal trauma- as in fall from a standing height or less; 3-transverse or short oblique configuration; 4-non- comminuted; and 5-complete fractures extending through both cortices and may be associated with medial spike; incomplete fractures involving only the lateral cortex) [33]. By consensus, these reviewers classified each patient as having (if all features were present) or not having atypical femoral fractures.

Statistical Analysis

We defined suspected subtrochanteric and diaphyseal femoral fracture cases according to several alternative algorithms based on ICD-9 diagnosis codes, with the goal of identifying the algorithm that maximized positive predictive value (PPV). Our algorithms incorporated hospital diagnosis codes assigned by a medical coder (i.e., hospital discharge diagnosis code) and physician diagnosis codes assigned by the attending orthopedic surgeon. For those patients receiving outpatient care after they were discharged, we also included outpatient clinic diagnosis codes assigned by the attending orthopedic surgeon. We computed the PPV of each claims-based algorithm as the proportion with cases identified by each algorithm that was confirmed by medical record review. Ninety-five percent confidence intervals were approximated using the binomial distribution. Statistical analysis was performed with SPSS, version 17.0 (SPSS Inc, Chicago, IL, USA).

Results

The mean $\pm$ SD age of hip and femur fractures was 48 ± 21 years (median 46, range 16-103 years), and 36% were women (Table 1). One hundred and eighty four (71%) patients revisited UAB outpatient clinic after discharge from the hospital. The mean length of time elapsed after hospital discharge until their last outpatient visit (days $\pm$ SD) was 32 ± 60 days

(median 16, range 1-548 days). Major trauma ICD-9 codes on hospital discharge data were found in 166 (71%) cases. While the majority of patients with subtrochanteric and diaphyseal femoral fracture diagnoses had one of the major trauma codes (81% and 87%, respectively), only half of patients with typical hip fractures had these trauma codes.

Medical record review identified 231 (98%) cases as incident fractures and 4 (2%) as prevalent fractures. Only two patients had more than one event over the observation period. Forty-two (18%) patients had discordance of fracture site between the radiology reports, operative notes, and the discharge summary diagnosis. A history of major trauma, defined as fractures due to a high impact or high velocity injury and unlikely to be due to osteoporosis alone, was found in the medical records of 176 (75%) cases. Of these patients, major trauma ICD-9 codes on hospital discharge data were correctly assigned in 160 (91%) cases. Among those without history of major trauma, 3 (4%) patients had cancer, one each with metastatic breast cancer, multiple myeloma and acute lymphocytic leukemia that could compromise the integrity or strength of the skeletal system. Review of the medical records of the 235 patients with a suspected subtrochanteric femoral fracture, diaphyseal femoral fracture, or hip fracture other than subtrochanteric and diaphyseal femoral fracture (typical hip fracture) indicated that 17 patients had fractures involving more than 1 femoral site [subtrochanteric and diaphyseal femoral fracture (5 patients), diaphyseal femoral fracture and typical hip fracture (2 patients), or subtrochanteric femoral fracture and typical hip fracture (10 patients)].

The positive predictive value (PPV) of an ICD-9 code to identify a subtrochanteric femoral fracture ranged from 69% to 89% based on the position (e.g. primary vs. non-primary) of the diagnosis code on the discharge claim and source of diagnosis codes (discharge diagnosis or inpatient surgeon's diagnosis) (Table 2). The misclassification we identified was due to the code for subtrochanteric femoral fracture being inappropriately assigned to patients with a confirmed diaphyseal femoral fracture or typical hip fracture in 31% of cases. PPVs for diaphyseal femoral fracture and typical hip fracture were slightly greater, ranging from 85 to 97%. For the algorithm based on the ICD-9 codes in the primary position on a hospital discharge record, PPVs for subtrochanteric and diaphyseal femoral fractures, and typical hip fracture were 74%, 94%, and 94%, respectively. Exclusion of patients who had discordance ($n=42$) between radiology report, operative note, and discharge summary diagnosis only slightly changed PPVs (70%, 97%, and 93% for subtrochanteric and diaphyseal femoral fractures and typical hip fracture, respectively). For subtrochanteric femoral fractures, the algorithm that required both a primary hospital discharge diagnosis code and the same diagnosis code from the surgeon who performed the fracture repair had the highest PPVs (89%). However, use of this algorithm markedly reduced the number of cases identified. The algorithms for diaphyseal femoral fracture and typical hip fracture that required a diagnosis code from the surgeon who performed the fracture repair had the highest PPVs (98%). A more specific case algorithm for diaphyseal femoral fracture and typical hip fracture that required both primary discharge diagnosis and the same diagnosis code from the surgeon resulted in the same PPV, but this algorithm identified a smaller number of cases than the algorithm that required only the surgeon's diagnosis.

Since fractures that occur in the subtrochanteric area can be easily misclassified by coding as diaphyseal fractures, we combined subtrochanteric and diaphyseal femoral fractures into a single femoral fracture group and allowed misclassification between these 2 types of fracture. The PPVs of various algorithms to identify this combined femoral fracture group were greater than those for each group separately (Table 2).

Of patients followed up at the UAB outpatient clinic after hospital discharge, case algorithms that required both a primary hospital discharge diagnosis code and the same diagnosis code on an outpatient physician claim within 90 days after discharge from hospital had PPVs of 86%, 96%, and 95% for subtrochanteric and diaphyseal femoral fractures, and typical hip fracture, respectively.

In a subgroup analysis (table 2), the PPVs of the various algorithms for subtrochanteric femoral fracture and typical hip fracture among patients age > 55 years and among patients without major trauma ICD-9 codes were the similar as those in the primary analysis. In contrast, the PPVs of algorithms for diaphyseal femoral fracture were lower for these subgroups than those in primary analysis. However, the number of confirmed diaphyseal femoral fracture cases in these subgroups was small.

Eleven patients had radiographs defined by the two reviewers as indicative of an atypical femoral fracture as established by the ASBMR [33]. Their age ranged from 20-70 years and 63% (7 of 11) had high trauma ICD-9 codes. These atypical femoral fracture sites were a mix between subtrochanteric (6 of 11) and diaphyseal (5 of 11) fractures. Of the 11 patients, only 4 patients had atypical femoral fractures that were not associated with trauma. The PPV of administrative codes for atypical femoral fractures was low and imprecise (Table 3), and was not meaningfully improved by relying on the surgeons' coding only.

Discussion

We found that administrative claims-based algorithms using ICD-9 codes can identify cases of subtrochanteric and diaphyseal femoral fractures, and typical hip fracture with relatively high PPVs. The PPV to identify subtrochanteric femoral fracture was slightly lower than the PPV to identify diaphyseal femoral fracture and typical hip fracture. Algorithms that required the fracture diagnosis code to be the primary hospital discharge diagnosis proved to have higher PPVs than the algorithm that require ICD-9 code on any position in hospital discharge diagnosis. For subtrochanteric femoral fracture, a still more specific case algorithm that required a subtrochanteric femoral fracture diagnosis code both as the primary discharge diagnosis and as the surgeon's diagnosis resulted in the greatest PPV. Although claims data was useful in defining the site of fracture, it was not useful in identifying radiographically-defined atypical femoral fractures, which were very few in number in our study and most commonly seen among younger adults.

The PPV to identify diaphyseal femoral fracture in our study is comparable to the PPV of 87% found by Tennessee Ray and colleagues who used an algorithm that included ICD-9 diagnosis, hospital procedure code, physician's current procedural terminology identification and radiology codes to identify diaphyseal femoral fracture [30]. However, in a recent study

by Sprangler and colleagues, the PPV for the various 821 sub-codes ranged from 83% for ICD-9 821.01 code to 20% for 821.00 code [32]. In our study, we combined all 821 sub-codes together (821.00 and 821.01) and found a higher PPV (89%, 95%CI 81-97). Furthermore, a specific case algorithm that required a diaphyseal femoral fracture diagnosis code both as the primary discharge diagnosis and as the surgeon's diagnosis resulted in the greatest PPV (97%, 95%CI 90-100). In a recent study, Park-Wyllie and colleagues validated ICD-10 codes (S72.2 and S72.3) for hospitalized subtrochanteric and diaphyseal femoral fractures [25]. They found the PPV to be 90% (95% CI 88-92), which is also comparable to the PPV of ICD-9 codes for same sites, which we found to be 92-96% (95% CI 88-100), dependent on the source of these codes.

Observational studies relying only on ICD-9 codes in hospital discharge diagnosis will lead to a modest overestimation of subtrochanteric fractures. In our study, this overestimation was mainly the result of the incorrect use of the 820.22 code. Causes of misclassification include ambiguity of terms, inaccurate or missing information in the patient record and variation and errors in clinical diagnoses. While the subtrochanteric femoral fracture ICD-9 code (820.22) on hospital discharge diagnosis had the lowest PPV in our study (PPV 74%, 95%CI 66-82), its reliability is comparable to other diagnostic codes that are used in epidemiologic and health services research [34,35].

Our study has the advantage of being based on a large sample of institutional data that included a relatively sizable number of femoral fracture events for which all had medical records available to review. We also were able to compare various permutations of claims-based algorithms to maximize the accuracy of hip fracture algorithms. Furthermore, our study used a detailed radiography and chart review as the reference standard. Our study was however, limited to patients with specific ICD-9 codes on the hospital discharge diagnosis list; therefore, the sensitivity, specificity and negative predictive value could not be determined in this analysis and we could not directly compare the PPV of diagnosis code on the discharge diagnosis with the PPV of a diagnosis code on the physician's claim. As we studied population of 'all- comers', not restricted to only older people or only to bisphosphonate users, the PPV is influenced by the prevalence of the condition under study. The use of data from one medical center with inherent institutionally-specific coding practice also is a study limitation. In a subgroup analysis, wide confidence intervals were observed in some subgroups as the number of confirmed cases was small.

In summary, administrative claims data-based algorithms that combined hospital discharge with the inpatient surgeon's diagnosis codes to identify cases of subtrochanteric and diaphyseal femoral fractures, and typical hip fracture yielded relatively high PPVs, particularly for diaphyseal femoral fracture and typical hip fracture. While only half of the patients with typical hip fractures had associated major trauma codes, most patients with subtrochanteric and diaphyseal femoral fractures had at least one major trauma code in our study. A case algorithm that required a subtrochanteric femoral fracture diagnosis code both as the primary discharge diagnosis and as the surgeon's diagnosis resulted in the highest PPV. However, administrative data was not successful in defining atypical femoral fractures. Although claims were not useful by themselves to identify atypical femoral fractures, claims data could be used as the first part of a two-stage case-finding strategy to

validly identify atypical subtrochanteric and femoral fractures. After preliminary identification of these fractures in the claims data, a second stage procedure of reviewing radiograph images could provide the needed specificity. These claims algorithms will be useful in future population-based observational studies to evaluate the association between osteoporosis medications such as bisphosphonates and subtrochanteric and diaphyseal fractures.

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Appendix 1. ICD-9 Codes for Identifying Subtrochanteric, Diaphyseal, and Typical Hip Fracture and Selected Exclusions

Description of Codes	ICD-9 Codes Used in Study
ICD-9 codes for identifying subtrochanteric fracture	820.22
ICD-9 codes for identifying diaphyseal fracture	821.0x
ICD-9 codes for identifying typical hip fracture	820.0x, 820.20, 820.21, 820.8
ICD-9 codes for identifying major trauma	E800-E848, E881-E884, E908-E909, E916-E928
ICD-9 codes used to exclude patients with open femoral fracture and distal end femoral fractures	820.1x, 820.3x, 820.9, 821.1x, 821.2x, 821.3x

An 'x' indicates that all subcodes were included.

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Figure 1. Identification of patients with suspected subtrochanteric and diaphyseal femoral fractures and hip fractures other than subtrochanteric and diaphyseal femoral fractures

*Femoral fracture (ICD-9; 820.xx, 821.xx, 733.14, and 733.15)

†Subtrochanteric fracture (ICD-9; 820.22)

‡Diaphyseal fracture (ICD-9; 821.00 and 821.01)

§Typical hip fracture (ICD-9; 820.00, 820.01, 820.02, 820.03, 820.09, 820.20, 820.21, and 820.8)

Table 1
Characteristics of patients with suspected subtrochanteric and diaphyseal femoral fractures and hip fractures other than subtrochanteric and diaphyseal femoral fractures

	All patients (n = 235)	Subtrochanteric fracture* (n = 137)	Diaphyseal fracture [†] (n = 55)	Typical hip fracture [‡] (n = 60)
Age (Mean ±SD)	48 ± 21	45 ± 20	41 ± 20	57 ± 23
Female (%)	36	32	38	43
Presence of major trauma code [§] (%)	71	81	87	53

* Subtrochanteric fracture (ICD-9; 820.22)

[†] Diaphyseal fracture (ICD-9; 821.00 and 821.01)

[‡] Typical hip fracture (ICD-9; 820.00, 820.01, 820.02, 820.03, 820.09, 820.20, 820.21, and 820.8)

[§] Major trauma code (ICD-9; E800-E848, E881-E884, E908-E909, and E916-E928)

Table 2
Positive Predictive Value (PPV) of the Case Identification Algorithms for Subtrochanteric, Diaphyseal, and Typical Hip Fractures

Case Identification Algorithm	Subgroup analyses					
	All patients			Patient age > 55 years		
	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)
Subtrochanteric Femoral Fractures						
· Any position on hospital discharge diagnosis list (primary or other)	137 (100)	69 (61-76)	43 (100)	72 (59-86)	33 (100)	76 (61-90)
· Primary hospital discharge diagnosis	107 (78)	74 (66-82)	37 (86)	78 (65-92)	28 (85)	82 (68-96)
· Surgeon's diagnosis on administrative claim	87 (64)	82 (73-90)	31 (72)	81 (67-95)	25 (76)	80 (67-93)
· Both primary discharge diagnosis AND surgeon's diagnosis	62 (45)	89 (81-97)	30 (70)	93 (84-100)	21 (64)	91 (78-100)
Diaphyseal Femoral Fractures						
· Any position on hospital discharge diagnosis list (primary or other)	55 (100)	89 (81-97)	12 (100)	67 (40-93)	9 (100)	78 (51-100)
· Primary hospital discharge diagnosis	35 (64)	94 (87-100)	8 (67)	80 (52-100)	7 (78)	86 (60-100)
· Surgeon's diagnosis on administrative claim	46 (84)	98 (93-100)	7 (58)	86 (60-100)	8 (89)	88 (65-100)
· Both primary discharge diagnosis AND surgeon's diagnosis	31 (56)	97 (90-100)	7 (58)	86 (60-100)	6 (67)	83 (54-100)
Subtrochanteric or Diaphyseal Femoral Fractures						
· Any position on hospital discharge diagnosis list (primary or other)	187 (100)	92 (88-96)	54 (100)	82 (71-92)	42 (100)	81 (69-93)
· Primary hospital discharge diagnosis	142 (76)	94 (90-98)	45 (83)	87 (77-97)	35 (83)	86 (74-97)
· Surgeon's diagnosis on administrative claim	133 (71)	98 (95-100)	38 (70)	90 (80-99)	33 (79)	88 (77-99)
· Both primary discharge diagnosis AND surgeon's diagnosis	93 (50)	96 (92-100)	37 (69)	95 (87-100)	27 (64)	93 (83-100)
Typical Hip Fractures						
· Any position on hospital discharge diagnosis list (primary or other)	187 (100)	92 (88-96)	54 (100)	82 (71-92)	42 (100)	81 (69-93)
· Primary hospital discharge diagnosis	142 (76)	94 (90-98)	45 (83)	87 (77-97)	35 (83)	86 (74-97)
· Surgeon's diagnosis on administrative claim	133 (71)	98 (95-100)	38 (70)	90 (80-99)	33 (79)	88 (77-99)
· Both primary discharge diagnosis AND surgeon's diagnosis	93 (50)	96 (92-100)	37 (69)	95 (87-100)	27 (64)	93 (83-100)

Case Identification Algorithm	Subgroup analyses					
	All patients		Patient age > 55 years		Patient without major trauma code [†]	
	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)	Number of identified cases by different algorithms (%) [*]	PPV (95% CI)
· Any position on hospital discharge diagnosis list (primary or other)	60 (100)	85 (76-94)	28 (100)	93 (83-100)	22 (100)	91 (79-100)
· Primary hospital discharge diagnosis	32 (53)	94 (85-100)	20 (71)	90 (77-100)	24 (86)	89 (74-100)
· Surgeon's diagnosis on administrative claim	49 (82)	98 (94-100)	26 (93)	96 (89-100)	26 (93)	95 (86-100)
· Both primary discharge diagnosis AND surgeon's diagnosis	29 (48)	97 (90-100)	19 (68)	95 (85-100)	22 (79)	95 (85-100)

* Compared to a case finding algorithm that accepted any SFF or DFF diagnosis on any position of hospital discharge diagnosis list

[†] Major trauma codes: E800-E848, E881-E884, E908-E909, and E916-E928.

Table 3

Case Identification Algorithm for atypical fractures	Subgroup analysis							
	All patients			Patient age > 55 years				
	Cases identified n (%) [*]	ppv (95% CI)	Cases identified n (%) [*]	ppv (95% CI)	Patient without major trauma code [‡]	Patient age > 55 years and without major trauma code ^{**}		
· Any position on hospital discharge diagnosis list (primary or other)	187 (100)	6 (3-10)	54 (100)	4 (0-13)	42 (100)	10 (3-23)	27 (100)	4 (0-20)
· Primary hospital discharge diagnosis	142 (76)	6 (3-11)	45 (83)	4 (3-13)	35 (83)	10 (3-24)	23 (85)	4 (0-21)
· Surgeon's diagnosis on administrative claim	133 (71)	7 (4-12)	38 (70)	5 (4-16)	33 (79)	13 (5-29)	21 (78)	5 (0-26)
· Both primary discharge diagnosis AND surgeon's diagnosis	93 (50)	7 (4-14)	37 (69)	8 (1-25)	27 (64)	9 (1-29)	16 (60)	7 (0-34)

Atypical femoral fracture were defined by consensus of two reviewers' assessment of the radiographs for features of atypical femoral fractures

⁴ Compared to a case finding algorithm that accepted any subtrochanteric femoral fracture or diaphyseal femoral fracture diagnosis on any position of hospital discharge diagnosis list

Major trauma codes: E800-E848, E881-E884, E908-E909, and E916-E928.