Online Supplementary Table 1: Sensitivity of Second Fracture Rates to Decisions about length of Period with no Intervening Claims for a Fracture of the Same type (7 days, 30 days, 60 days, 90 days, 120 days, 180 days).

	Fracture Rate within one year per 1000 person years	
	Index Fracture Type	
Length of Clean Period	Wrist	Shoulder
30 days	8.53	5.72
60 days	5.23	5.20
90 days	4.92	5.02
120 days	4.75	4.87
180 days	4.49	4.70

Online Supplementary Table 2: Predicted Probability of a Second Fracture in One Year based on Fully Interacted Cox Proportional Hazards Model* (percentage with second fracture with 95% confidence interval)

		66-74 years old		75-84 years old		85+ years old	
Index Fracture Type	Comorbidity	Female	Male	Female	Male	Female	Male
Hip	0	4.7 (4.1-5.4)	3.8 (2.7-4.8)	5.7 (5.2-6.1)	4.0 (3.2-4.8)	6.6 (6.2-7.0)	4.4 (3.5-5.3)
	1	5.8 (5.0-6.6)	4.3 (3.2-5.4)	6.9 (6.4-7.4)	4.7 (3.9-5.5)	6.7 (6.3-7.2)	4.8 (4.0-5.7)
	2	7.2 (6.1-8.2)	6.2 (4.7-7.8)	7.9 (7.2-8.5)	5.0 (4.1-5.9)	7.3 (6.7-7.8)	5.6 (4.6-6.6)
	>=3	7.0 (6.3-7.8)	6.0 (5.1-6.9)	7.6 (7.1-8.0)	6.0 (5.4-6.6)	6.8 (6.4-7.2)	6.1 (5.5-6.7)
Shoulder	0	2.8 (2.3-3.3)	2.4 (1.3-3.5)	4.0 (3.5-4.6)	4.6 (3.1-6.2)	7.0 (6.1-7.9)	5.1 (3.0-7.2)
	1	3.8 (3.0-4.6)	2.0 (0.8-3.2)	5.6 (4.8-6.4)	5.9 (4.0-7.7)	8.0 (6.8-9.1)	5.1 (2.7-7.4)
	2	4.9 (3.5-6.2)	5.6 (2.8-8.4)	7.4 (6.2-8.7)	5.6 (3.3-7.9)	9.4 (7.7-11.0)	4.7 (2.0-7.4)
	>=3	5.0 (4.0-6.0)	5.5 (3.6-7.3)	6.1 (5.2-7.0)	4.9 (3.6-6.2)	7.1 (5.8-8.5)	7.7 (5.4-9.9)
Wrist	0	2.5 (2.2-2.7)	2.3 (1.6-2.9)	4.3 (3.9-4.6)	2.7 (1.9-3.6)	6.6 (6-7.2)	5.1 (3.3-6.8)
	1	4.2 (3.6-4.8)	1.5 (0.7-2.3)	6.2 (5.6-6.8)	4.8 (3.3-6.2)	8.1 (7.2-8.9)	8.4 (5.5-11.2)
	2	6.6 (5.4-7.8)	3.1 (1.4-4.7)	5.7 (4.9-6.6)	3.9 (2.1-5.6)	8.9 (7.6-10.1)	7.9 (4.4-11.3)
	>=3	5.4 (4.5-6.2)	4.3 (3.0-5.6)	6.5 (5.7-7.2)	6.4 (5.0-7.7)	7.0 (6.0-7.9)	7.5 (5.5-9.5)

*Model includes type of index fracture, age, gender, race, and comorbidity with the four-way interaction between type, age, gender, comorbidity

Online Supplementary Table 3: Cox Proportional Hazard Model for Time to Second Fracture after an Incident Hip, Humerus, or Wrist Fracture among FFS Medicare beneficiaries over the age of 66 in 2009

	Parameter	Estimate	StdErr	ChiSq	p-value
type of index fx (reference=hip)	Wrist	-0.519	0.204	6.510	0.011
	Humerus	-0.461	0.273	2.840	0.092
age (reference=66-74)	age 75-84	0.060	0.174	0.121	0.728
	age 85+	0.169	0.175	0.942	0.332
sex (reference=female)	Male	0.233	0.156	2.219	0.136
race (reference=white)	black	-0.315	0.056	31.497	<.0001
	asian	-0.217	0.083	6.862	0.009
	hispanic	-0.155	0.048	10.478	0.001
	other	-0.050	0.092	0.289	0.591
Charlson score (reference=0)	Charlson Score=1	0.145	0.191	0.574	0.449
	Charlson Score=2	0.518	0.190	7.429	0.006
	Charlson Score=3	0.486	0.159	9.325	0.002
	Wrist*age 75-84	0.140	0.278	0.253	0.615
	Wrist*age 85+	0.660	0.293	5.058	0.025
	Humerus*age 75-84	0.617	0.339	3.303	0.069
	Humerus*age 85+	0.614	0.363	2.865	0.091
	Wrist*Male	-0.141	0.224	0.396	0.529
	Humerus*Male	-0.068	0.299	0.052	0.819
	Male*age 75-84	0.132	0.192	0.472	0.492
	Male*age 85+	0.175	0.192	0.834	0.361
	Wrist*Male*age 75-84	0.232	0.299	0.601	0.438
	Wrist*Male*age 85+	-0.003	0.313	0.000	0.992
	Humerus*Male*age 75-84	-0.443	0.369	1.443	0.230
	Humerus*Male*age 85+	-0.027	0.389	0.005	0.944
	Wrist*Charlson Score=1	-0.568	0.368	2.382	0.123
	Wrist*Charlson Score=2	-0.198	0.368	0.290	0.590
	Wrist*Charlson Score=3	0.170	0.267	0.406	0.524
	Humerus*Charlson Score=1	-0.322	0.438	0.539	0.463

Humerus*Charlson Score=2	0.358	0.398	0.808	0.369
Humerus*Charlson Score=3	0.357	0.333	1.148	0.284
age 75-84*Charlson Score=1	0.028	0.235	0.015	0.904
age 75-84*Charlson Score=2	-0.281	0.235	1.424	0.233
age 75-84*Charlson Score=3	-0.065	0.196	0.111	0.739
age 85+*Charlson Score=1	-0.057	0.237	0.058	0.809
age 85+*Charlson Score=2	-0.277	0.236	1.380	0.240
age 85+*Charlson Score=3	-0.151	0.198	0.581	0.446
Wrist*age 75-84*Charlson Score=1	0.963	0.452	4.536	0.033
Wrist*age 75-84*Charlson Score=2	0.306	0.485	0.400	0.527
Wrist*age 75-84*Charlson Score=3	0.268	0.349	0.592	0.442
Wrist*age 85+*Charlson Score=1	1.003	0.470	4.557	0.033
Wrist*age 85+*Charlson Score=2	0.416	0.491	0.720	0.396
Wrist*age 85+*Charlson Score=3	-0.104	0.373	0.078	0.780
Humerus*age 75-84*Charlson Score=1	0.392	0.518	0.572	0.450
Humerus*age 75-84*Charlson Score=2	-0.398	0.502	0.627	0.429
Humerus*age 75-84*Charlson Score=3	-0.715	0.417	2.948	0.086
Humerus*age 85+*Charlson Score=1	0.224	0.562	0.159	0.690
Humerus*age 85+*Charlson Score=2	-0.690	0.560	1.517	0.218
Humerus*age 85+*Charlson Score=3	-0.278	0.442	0.397	0.529
Male*Charlson Score=1	0.068	0.216	0.099	0.753
Male*Charlson Score=2	-0.089	0.219	0.165	0.685
Male*Charlson Score=3	-0.073	0.184	0.159	0.690
Wrist*Male*Charlson Score=1	0.893	0.394	5.138	0.023
Wrist*Male*Charlson Score=2	0.775	0.400	3.755	0.053
Wrist*Male*Charlson Score=3	0.210	0.299	0.491	0.484
Humerus*Male*Charlson Score=1	0.416	0.473	0.773	0.379
Humerus*Male*Charlson Score=2	-0.222	0.447	0.247	0.619
Humerus*Male*Charlson Score=3	-0.183	0.375	0.238	0.626
Male*age 75-84*Charlson Score=1	-0.047	0.262	0.032	0.858
Male*age 75-84*Charlson Score=2	0.185	0.266	0.487	0.486
Male*age 75-84*Charlson Score=3	-0.052	0.223	0.054	0.817
Male*age 85+*Charlson Score=1	-0.135	0.262	0.266	0.606

Male*age 85+*Charlson Score=2	-0.051	0.265	0.037	0.848
Male*age 85+*Charlson Score=3	-0.229	0.224	1.050	0.306
Wrist*Male*age 75-84*Charlson Score=1	-1.098	0.481	5.205	0.023
Wrist*Male*age 75-84*Charlson Score=2	-0.925	0.521	3.153	0.076
Wrist*Male*age 75-84*Charlson Score=3	-0.526	0.385	1.869	0.172
Wrist*Male*age 85+*Charlson Score=1	-1.135	0.498	5.190	0.023
Wrist*Male*age 85+*Charlson Score=2	-0.779	0.525	2.199	0.138
Wrist*Male*age 85+*Charlson Score=3	-0.250	0.409	0.372	0.542
Humerus*Male*age 75-84*Charlson Score=1	-0.345	0.561	0.379	0.538
Humerus*Male*age 75-84*Charlson Score=2	0.561	0.557	1.015	0.314
Humerus*Male*age 75-84*Charlson Score=3	0.677	0.466	2.113	0.146
Humerus*Male*age 85+*Charlson Score=1	-0.198	0.600	0.109	0.742
Humerus*Male*age 85+*Charlson Score=2	0.762	0.610	1.560	0.212
Humerus*Male*age 85+*Charlson Score=3	0.097	0.492	0.039	0.843

Online Supplementary Methodological Appendix

Overview

Identifying Index Fracture The general approach to identifying an index fracture was to require a claim with an appropriate diagnosis and treatment without a similar fracture in the prior year. We also applied additional rules when necessary to assure that the event indicated a new fracture rather than follow up care.

Inclusion

Treated as an Inpatient

Hip fractures were identified by an acute care hospitalization with an appropriate ICD-9 diagnostic code (Table 1) and a DRG or ICD-9 procedure code indicating surgical repair (Table 2). Humerus and wrist fracture can be treated as inpatient or outpatient and are less likely to be treated with surgery making differentiation of new fracture from follow up care more challenging to distinguish. For inpatient treatment, we required both diagnosis and indication of treatment as with hip. Wrist and humerus ICD-9 diagnostic, DRG and ICD-9 procedure codes are shown in Tables 1 and 2.

Table 1: ICD-9 Diagnostic Codes

	ICD-9 DX	
HIP	820.00-820.90	neck
	821.00-821.11	shaft
WRIST	813.40-813.54	
HUMERUS	812.00-812.19	

Table 2: DRG and Procedure Codes		
	DRG	**ICD-9 SX**
HIP	469-470	78.55, 79.10, 79.15, 79.30, 79.35, 81.51, 81.52
WRIST OR HUMERUS	483-484	
WRIST	513-514	79.02, 79.12, 79.32, 79.22, 78.53, 78.13
HUMERUS	507-512	79.01, 79.31, 78.52, 78.12

Treated as an Outpatient

For outpatient treatment, there are visits not only for acute management of a fracture but also aftercare such as cast changes and repeat imaging. To avoid including a patient who was merely having aftercare for a previous fracture, we required a claim with the appropriate diagnosis and treatment code (CPT on Part B claims) along with a claim for appropriate imaging within seven days before or after the treatment claim, in addition to having no similar fracture in the prior year. The sane diagnostic codes were used for outpatient cases and inpatient cases. Treatment was indicated by presence of particular CPT codes as shown in Table 3. And imaging of the appropriate region with plain x-ray, CT scan, or MRI were accepted shown in Table 4

Table 3: CPT Treatment Codes	
	CPT code
WRIST	25600, 25605, 25609, 25606, 25607, 25608, 25650, 29075, 29085, 29125
HUMERUS	23600, 23605, 23615, 23616, 23620, 23625, 23630, 23665, 23670, 23675, 24500, 23470, 23472, 29065, 29105, 29125, 23620

Table 4: Identifying Imaging for the Non-Hip Fractures Imaging CPT Codes			
	Plain	**CT**	**MRI**
HIP	N/A	N/A	N/A
WRIST	73090, 73092, 73100, 73110, 73115	73200, 73201, 73202, 73206	73218, 73219, 73220, 73221, 73222, 73223, 73225
HAND	73120, 73130, 73140		
HUMERUS	Shoulder/Clavicle 73000, 73010, 73020, 73030, 73040, 73050	73200, 73201, 73202, 73206	73218, 73219, 73220, 73221, 73222, 73223, 73225
	Elbow 73060, 73070, 73080, 73085		

Exclusions

We applied exclusions to remove people who were receiving treatments that suggest the event was not an incident osteoporosis-related fracture, such as treatment that was the result of a cancer diagnosis, multitrauma, or complications of a prior fracture (such as indicators for mal-or non-union, infection, revision, or hardware removal). In the case of fractures due to cancer, we excluded fractures with a diagnostic code indicating "pathologic" (Table 4) and the presence of cancer in the year before or one month after the fracture (to account for cases when the fracture is the initial presentation of the cancer). We included in our list of cancers only those know to be primary to bone or to commonly metastasize to bone (Table 5). We did not exclude all fracture indicated as "pathologic" because some clinicians refer to fractures due to any bone disease, including osteoporosis, as pathologic. The codes for identifying multi-trauma and complications treated in the inpatient setting are shown in Table 6 and in the outpatient setting in Table 7.

Table 4: Codes for "Pathologic" Fractures	
	ICD-9 DX
HIP	733.14, 733.15
WRIST	733.12
HUMERUS	733.11
	DRG
Any Fracture (Hip, Humerus or Wrist)	542, 543, 544

Table 5: Codes for Non-Osteoporosis Related Fractures	
	ICD-9 Dx
Breast Cancer	174.0-174.9
Lung Cancer	162.2-162.9
Thyroid Cancer	193
Renal Cell	189.0-189.1
Prostate Cancer	185
Colon Cancer	153.0-153.9
Multiple Myeloma	203.0
Myeloma (solitary)	238.6
Chondrosarcoma	170.9
Osteosarcoma	170.7
Paget's Disease	731.0
Osteopetrosis	756.52
Osteomyelitis	730.0-730.9

Table 6: Codes for Multi-Trauma and Complications of Previous Fracture				
		MedPAR (DRG)	MedPAR (ICD-9 SX)	Carrier/Outpt (CPTs)
Any Fracture (Hip, Humerus or Wrist)	Multiple Trauma	955, 957, 958, 959, 963, 964, 965	NA	NA
	Hardware removal	None	78.6	20680, 20670
	Mal/Nonunion	None	78.5	
HIP	Multiple Trauma	956	None	
	Revision	466, 467, 468	81.53, 00.7, 00.71, 00.72, 00.73	
	Hardware removal	None		27090, 27091
	Mal/Nonunion	None	None	27470, 27472
WRIST	Multiple Trauma	None	None	
	Revision	None	None	
	Hardware removal	None	None	25248, 25250, 25251
	Mal/Nonunion	None	None	25350, 25400, 25405, 25415, 25420
HUMERUS	Multiple Trauma	No additional	None	
	Revision	None	None	
	Hardware removal	None	None	23040, 23107, 23330, 23331, 23332
	Mal/Nonunion	None	None	24400, 24430, 24435

Table 7: Codes for Outpatient Treatment of Complications	
Any Fracture (Hip, Humerus or Wrist)	20680, 20670
WRIST	25248, 25250, 25251, 25350, 25400,25405, 25415, 25420
HUMERUS	23040, 23107, 23330, 23331, 23332, 24400, 24430, 24435

Multiple Fracture on Index Date

Some individuals had multiple index fractures on the same day (ex. a hip and wrist fracture from the same fall). In these cases, we attributed the person to the fracture category of greatest functional impact (hip>humerus>wrist).

Identifying Second Fracture

Hip

The occurrence of second hip, humerus, or wrist fracture was determined using the same approach to identifying the index fracture. Adaptations had to made to distinguish follow up care for the index fracture versus a new secondary fracture because we cannot distinguish fractures that occur on the right or left side. When the secondary fracture was treated in the hospital with surgery, the indications for treatment are specific enough that there is high confidence that the fracture is new once we apply the exclusion criteria above. When the secondary fracture is at an entirely different site (for example, a wrist fracture after hip), there is also high confidence it represents a new subsequent fracture especially because we exclude any secondary fractures if that same type of fracture occurred within the prior year.

Wrist or Humerus

For wrist and humerus fractures that most often are treated without surgery, it challenging to distinguish a secondary fracture from follow-up care for the index fracture when the sequence is wrist followed by wrist or humerus followed by humerus because treatment is similar (ex. casting and re-casting appear the same in the claims). To address this issue, we additionally required a clean period with no claims for the fracture. We tested the sensitivity of our results to different length clean periods and present those results. Based on the sensitivity analysis and clinical judgment, we decided to apply a 90 day clean period in the final analysis.

Other Upper or Lower Extremity Fracture

We were also interested in a more broad assessment of burden of secondary fracture incorporating other types of fracture that may be associated with osteoporosis. To do so, we also looked for the occurrence of other types of upper extremity or lower extremity fracture. For upper and lower extremity fracture, we applied a similar approach requiring no similar

fracture for year to exclude follow up care and selecting claims with an appropriate diagnosis and treatment indicator (Table 8).

Table 8 – Codes for Identifying Other Upper Extermity, Lower Extremity and Vertebral Fractures

	CPT (2010)	**ICD-9 (2010 & 2006)**	**Imaging Codes (cpt)**
UPPER EXTREMITY			
Clavicle	23500, 23505, 23515	810.xx	
Scapula	23570, 23575, 23585	811.xx	
Distal humerus	24530, 24535, 24538, 24545, 24546, 24560, 24565, 24566, 24575, 24576, 24577, 24579, 24582, 24586, 24587	812.4x, 812.5x	
Proximal Forearm	24620, 24635, 24650, 24655, 24665, 24666, 24670, 24675, 24685	813.0x, 813.1x	
Forearm shaft	25500, 25505, 25515, 25520, 25525, 25526, 25530, 25535, 25545, 25560, 25565, 25574, 25575	813.2x, 813.3x	
Unspecified forearm fx	Use dx CPTs in prox forearm and forearm shaft sections	813.8x, 813.9x, 818.xx, 819.xx	
LOWER EXTREMITY			
Pelvic	27193, 27194, 27200, 27202, 27215, 27216, 27217, 27218, 27220, 27222, 27226, 27227, 27228	808.x	72170, 72190, 72192, 72193, 72194, 72195, 72196, 72197, 73500, 73510, 73520, 73540
Femoral shaft	27500, 27501, 27502, 27503 27506, 27507, 27508, 27509, 27510, 27511, 2751327514	821.x other than 821.00-821.11	73550
Proximal Tibia	27530, 27532, 27535, 27536, 29855, 29856, 27538, 29850, 29851 27540	823.0x, 823.1x	73560, 73562, 73564
Tibial Shaft	27750, 27752, 27756, 27758, 27759	823.2x, 823.3x (823.8x, 823.9	73590, 73592
Ankle (distal tibia/ankle)	27760, 27762, 27766, (27767, 27768, 27769-(added between 2005 and 2010), 27780, 27781, 27784, 27786, 27788, 27792, 27808, 27810, 27814, 27816, 27818, 27822, 27823, 27824, 27825, 27826, 27827, 27828, 27829	824.xx	73600, 73610
Foot	28400, 28405, 28406, 28415, 28420, 28430, 28435, 28436, 28445, 28446 (added between 2005-2010), 28450, 28455, 28456, 28465, 28470, 28475, 28476, 28485, 28490, 28495, 28496, 28505, 28510, 28515, 28525, 28530, 28531	825.x, 826.x	73620, 73630
Lower Extremity-MRIs for all fx			73700-73725