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Clinical and Demographic Factors Associated with Fractures Among Older Americans

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Abstract

Purpose—This study investigates the associations of a history of fracture, comorbid chronic conditions, and demographic characteristics with incident fractures among Medicare beneficiaries. The majority of fracture incidence studies have focused on the hip and on white females. This study examines a greater variety of fracture sites and more population subgroups than prior studies.

Methods—We used Medicare claims data to examine the incidence of fracture at six anatomic sites in a random 5% sample of Medicare beneficiaries during the time period 2000 through 2005.

Results—For each type of incident fracture, women had a higher rate than men, and there was a positive association with age and an inverse association with income. Whites had a higher rate than nonwhites. Rates were lowest among African Americans for all sites except ankle and tibia/fibula, which were lowest among Asian Americans. Rates of hip and spine fracture were highest in the South, and fractures of other sites were highest in the Northeast. Fall-related conditions and depressive illnesses were associated with each type of incident fracture, conditions treated with glucocorticoids with hip and spine fractures and diabetes with ankle and humerus fractures. Histories of hip and spine fractures were associated positively with each site of incident fracture except ankle; histories of nonhip, nonspine fractures were associated with most types of incident fracture.

Conclusions—This study confirmed previously established associations for hip and spine fractures and identified several new associations of interest for nonhip, nonspine fractures.

Keywords

epidemiology; fractures; osteoporosis; incidence; Medicare

INTRODUCTION

Prospective cohort studies indicate that the incidence of fragility fractures increases with age (1–3), is higher among women than men (2–7), and is higher among whites than other ethnic

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sub-groups (8, 9). Other risk factors include low bone mineral density (10, 11), history of prior fracture (12–15), history of falls (16), chronic medical conditions including diabetes (16), renal disease (17), depressive illness (18), low body weight (19), and use of certain medications (e.g., glucocorticoids) (20). Much of this research has concentrated on hip fractures. Vertebral fractures have been less well-studied, and data on the incidence of nonhip, non-vertebral fractures are relatively sparse (21).

Medicare beneficiaries have a high risk of fragility fractures due to age. Research using Medicare claims data has estimated the incidence of fractures at various anatomic sites by age, race, and sex (4, 22–24) and by geographic region (25–28). Several other studies have evaluated a single fracture site (29–32). Studies of potential risk factors for fractures among Medicare beneficiaries have been limited to demographic factors, to a single clinical risk factor or to special populations, such as nursing facility patients (33–42). No study of Medicare beneficiaries has used nationwide data to analyze the relation between multiple clinical factors and the incidence of fractures at various sites.

We used recent Medicare claims data to examine the incidence of fracture at six anatomic sites in a sample of beneficiaries. The use of Medicare claims offers two distinct advantages. First, we are able to examine differences in fracture incidence by detailed population subgroups, including Asian- and Hispanic-Americans. Second, longitudinal claims data allow us to examine the association between prior fractures and chronic conditions and site-specific fracture incidence.

MATERIALS AND METHODS

Study design and data sources

We conducted a retrospective cohort study using claims from 2000 through 2005 for a 5% random sample of Medicare beneficiaries, obtained from the Center for Medicare and Medicaid Services (CMS) Chronic Condition Warehouse (43). The data consisted of beneficiaries' claims for all Medicare covered services and included International Classification of Diseases, Ninth Revision (ICD-9) diagnosis and procedure codes, as well as Healthcare Common Procedure Coding System (HCPCS) codes indicating surgical, diagnostic or other medical procedures performed. We used the Medicare data to identify cohorts at risk of developing fractures at six of the most common fracture sites among older adults (spine, hip, distal radius/ulna, tibia/fibula, humerus and ankle) and to identify incident cases of these fractures. The study protocol was approved by the Institutional Review Board at the University of Alabama at Birmingham and by CMS.

Eligibility

We studied a “baseline” cohort of beneficiaries who had fee-for-service coverage continuously for at least 13 months, were included in the 5% national sample, were 65 years of age or older as of their first month of coverage and lived in the fifty States or the District of Columbia. In order to minimize missing data and to ensure completeness of beneficiary data/case ascertainment, we excluded beneficiaries without both Medicare Parts A and B coverage and those enrolled in a Medicare Advantage plan at any time during the observation period. This restriction was necessary because medical care transactions for these beneficiaries may not be reported completely to CMS.

For the analysis of each specific fracture site, we further restricted the baseline cohort to beneficiaries who did not have any claim for that particular fracture during their first 12 months of Medicare coverage. We applied this restriction in order to avoid misclassification of prevalent fractures as incident fractures. Follow-up of beneficiaries began at the start of the thirteenth month of continuous enrollment in Medicare. Follow-up continued until the

occurrence of the first fracture of the site being analyzed, loss of full Medicare coverage, death or December 31, 2005, which ever was earliest.

Incident fractures

We identified incident fractures using ICD-9 diagnosis codes and HCPCS procedure codes specific to the particular fracture sites. Similar approaches have been used and validated by other investigators (4, 23, 44, 45). A “qualifying” claim for an incident fracture had to occur on or after the follow-up start date and before the end of the study period and had to be one of the following: 1) an inpatient hospital claim with a discharge diagnosis of the specific fracture (for spine fractures, we counted only primary diagnoses; for other fractures, we counted both primary and secondary diagnoses); 2) a physician or outpatient hospital claim for the fracture diagnosis code accompanied by a HCPCS code for a site-specific fracture repair; or 3) for spine fractures only, a physician evaluation and management claim with a spine fracture diagnosis code, plus, up to 10 days earlier, a HCPCS code for spine imaging (45). We selected fracture sites for inclusion in the analysis based on frequency of their occurrence in the Medicare data. Our fracture identification algorithms are available upon request.

Independent variables

Medical variables analyzed for possible associations with fracture included indicators for previous fractures at specific sites and comorbid chronic conditions, including glucocorticoid-related and fall-related (predisposing to falls) conditions, diabetes, renal disease, depressive illness, acute myocardial infarction, other heart disease, bone disease and cancer. The Appendix provides the ICD-9 diagnosis codes used to identify the chronic conditions. Glucocorticoid-related conditions included illnesses for which glucocorticoid medications typically are prescribed; we did not have data on actual medication use. Each claims-based medical history variable was treated as time-dependent and was measured on a monthly basis. In order to avoid misclassifying fractures and chronic conditions diagnosed concurrently with an incident fracture as medical history, in each month of follow-up we counted only those claims occurring at least three months earlier. We classified a beneficiary as having a history of the other chronic conditions if the beneficiary's inpatient, outpatient hospital or physician claims records included at least one claim with an ICD-9 code pertaining to the condition (see Appendix).

Demographic variables analyzed for possible associations with fracture were age, gender, race, urban or nonurban residence, geographic region and income. We analyzed age as of the start of follow-up and also as a time-varying covariate, using categories of 65–69, 70–74, 75–79, 80–84 and 85+ years. Categories of self-reported race/ethnicity were white (referent group), African-American, Asian-American, Hispanic-American and other. These data did not allow classification of the Hispanic-American population by race. We included Native Americans in the “other” category due to small numbers. We determined urban v. nonurban residential status by linking beneficiaries' nine-digit ZIP Codes to the rural-urban commuting area code for the corresponding census blockgroup (46, 47). We also used beneficiaries' ZIP Codes to assign them to one of four United States (US) Census Bureau-defined geographic regions: Northeast (referent group), Midwest, West or South. We assigned each beneficiary to an income category (<$30,000 (referent group), $30,000 to < $45,000, $45,000 to <$60,000, $60,000 to <$75,000 and $75,000 or more) by linking his or her census block group of residence (based on the nine-digit ZIP Code) to the Census 2000 median income data (48).

Statistical analysis

Descriptive analyses of the baseline cohort included frequency distributions and median values, where appropriate, for each demographic variable. We used Poisson regression to estimate adjusted rate ratios (RRs) and 95% confidence intervals (CIs) for each type of incident fracture, for the entire cohort and separately for women and men. The analytic approach allowed a person with a first fracture at a particular anatomic site to be eligible for subsequent fractures at other anatomic sites but not at the same site. RRs for each time-dependent medical history variable were adjusted for all demographic variables, as well as for all of the other medical history variables. We also performed an analysis stratified according to reported history of osteoporosis or osteopenia. A history of osteoporosis or osteopenia may have implications for a fracture being considered osteoporotic, particularly as we have not excluded fractures due to high trauma. Analyses were performed using SAS (SAS Institute, Inc., Cary, NC). We present results in tabular form for the entire cohort of women and men, combined, and mention gender-specific results in the text only when findings differed for women and men. Because of the large size of the study, conventional statistical significance was not a useful criterion for identifying results of potential interest. Thus, we focused instead on statistically significant results that had an RR of at least 1.2 or less than 0.9, both for women and for men.

RESULTS

The baseline cohort of 1,694,051 eligible beneficiaries was 58% women and 88% white and had a median age 72 years (Table 1). The median income in the census blocks where beneficiaries lived was $40,541 in 2000 dollars. About 73% of subjects began follow-up in 2000. Women and men were similar with regard to demographic variables. For each cohort, the average amount of follow-up was 4.2 person-years.

The number of incident fractures by site was largest for hip (N=60,354), followed by spine (N=44,075), distal radius/ulna (N=24,655), humerus (N=19,393), ankle (N=13,454) and tibia/fibula (N=6,385) (Table 2). The positive association with age was strongest for hip and spine fractures, intermediate for distal radius/ulna, humerus and tibia/fibula fractures and weakest for ankle fracture.

Men had a lower rate of each type of fracture than women. Median household income was associated inversely with the incidence of all six fracture types. Nonurban/urban residence was largely unassociated with incident fractures. Hip and spine fracture rates were highest in the South, whereas rates of the other four types of fracture were highest in the Northeast. Hip fracture was the only type of fracture displaying a trend of decreasing incidence over the six-year study period, and spine fracture was the only fracture for which the incidence appeared to increase during the study years. Asian, African, and Hispanic-Americans showed lower fracture incidence than white Americans for all sites, and Asian and African-Americans showed lower incidence than Hispanic-Americans for all sites. For fractures of the ankle and the tibia/fibula, incidence was lowest among Asian-Americans. For fractures of the hip, spine, distal radius/ulna, and humerus, incidence was lowest among African-Americans. Histories of hip and closed spine fractures were associated with each incident fracture site except ankle (Table 3). RRs for positive associations with a history of hip fracture ranged from 1.33 for incident distal radius/ulna fracture to 1.75 for incident tibia/fibula fracture. RRs for positive associations with a history of closed spine fracture ranged from 1.38 for incident distal radius/ulna fracture to 1.63 for incident hip fracture. For incident ankle fracture, a history of hip fracture was protective (RR=0.86), and there was no association with a history of spine fracture. History of fractures at nonhip, nonspine sites were associated positively with most types of incident fracture, although associations tended

to be weaker and less consistent for histories of carpal bone, femur (other than hip) and ankle fractures than for other nonhip, nonspine sites.

A history of glucocorticoid-related conditions was associated weakly with each type of incident fracture, but spine was the only incident fracture site for which the RR was at least 1.2 among both women (RR=1.44) and men (RR=1.54) (Table 3). Fall-related conditions and depressive illnesses were associated with an RR of at least 1.2 for each type of incident fracture. Diabetes was associated positively with ankle and humerus fractures. Other positive associations reported in Table 3 were inconsistent for women and men.

DISCUSSION

Compared with previous research on fractures among Medicare beneficiaries, our study examined a more recent time period, focused on minority and ethnic populations, and assessed a broader range of potential risk factors in relation to greater variety of nonhip, nonspine fracture sites. In particular, our assessment of income, fracture history and history of individual comorbid conditions as potential risk factors for incident fractures among Medicare beneficiaries is novel. The following discussion concentrates on several interesting associations emerging from these new analyses, including those pertaining to income and to history of prior fractures, diabetes, conditions for which glucocorticoid medications are prescribed and depressive illnesses.

We observed a decrease in hip fracture incidence and an increase in spine facture incidence over the six-year study period. A possible reason for the decrease in hip fractures, which has also been reported recently in another US study (49), and a Canadian study (50), is better screening and rates of treatment. It is possible that the apparent increase in spine fracture is attributable to improved detection and/or reporting, through both increased awareness of osteoporosis and increased screening.

We found an inverse relationship between median household income in a beneficiary's census block group, a proxy measure of socioeconomic status (SES), and incidence of each fracture. This relationship has been investigated previously in the US only for hip fracture, with results similar to ours (38, 51, 52). SES affects the likelihood of receiving screening and preventive services, medication adherence and overall health status. Thus, our finding underscores the need for targeted fracture interventions.

Prior fracture is a significant predictor of subsequent fracture among older adults (12, 13, 16, 53–59). In our study of Medicare beneficiaries, histories of typical osteoporotic fractures (hip, spine and distal radius/ulna) were associated positively and consistently with the incidence of each of the six fracture types analyzed, except for ankle fracture. Furthermore, prior fractures at most traditionally understudied, nonhip, nonspine sites, were associated positively and consistently for women and men with the incidence of traditional fragility fracture incidence sites (hip, distal radius/ulna and spine), as well as with fractures of the humerus and tibia/fibula. Among the nonhip, nonspine sites examined as prior history risk factors, associations were least consistent across the incident fracture sites for history of ankle, carpal bone and femur (other than hip) fractures than for history of other nonhip, nonspine sites – results consistent with previous research. In our study, a history of hip fracture was protective for incident ankle fracture. We speculate that this unexpected result might be due to lower mobility following a hip fracture and the consequent limited opportunity to sustain an ankle fracture.

Others have reported an association between depressive illnesses and fracture (60). Depressive illnesses are associated with many chronic conditions and may constitute a component of an overall frailty syndrome (61). In addition, depressive illnesses are often

treated with anti-depressants and sedatives, which increase the risk of falls (62). Furthermore, depressive illnesses have been independently associated with both low bone mineral density (63) and with fragility fractures (60). In our study group, the most common depressive illnesses were depressive disorders not elsewhere classified, neurotic depression, major depressive disorders and senile dementia depression.

We observed that a history of glucocorticoid-related conditions was associated weakly with all fracture types, but the relationship was characterized by an RR of at least 1.2 for both women and men only for spine fracture. These results are consistent with past research showing that long-term glucocorticoid use consistently leads to secondary, medication-induced osteoporosis and increased fracture risk, particularly for sites of trabecular bone such as the spine and hip (20, 53). It was somewhat surprising that our study found an RR as high as 1.47 for glucocorticoid-related conditions and spine fracture, given the relatively large amount of misclassification for this type of fracture (45), as well as the misclassification and diversity of the conditions presumed to be treated with glucocorticoids, the most common of which in our study group were chronic obstructive pulmonary disease, chronic bronchitis, asthma, rheumatoid arthritis and emphysema.

Previous studies of the relationship between diabetes and fractures have reported positive associations for fractures of the ankle (64, 65) and humerus (66, 67) that are consistent with our results. In contrast to previous research (68), we did not find an increased rate of hip fracture among people with a history of diabetes. Possible reasons for our null results include bias towards the null due to misclassification and our inability to analyze time since diagnosis and severity of diabetes. Multiple mechanisms by which diabetes may increase the risk of fracture have been proposed (69). Although diabetes is associated with higher bone mineral density, bone mineral density measurements may not fully reflect bone strength (69), and Thrailkill et al.(70) have suggested that insulin has an anabolic effect. Reduced skeletal load, which may result from physical inactivity often associated with diabetes, may decrease bone strength (71), and diabetic complications such as retinopathy, peripheral neuropathy and renal insufficiency, increase the risk of falls.

A history of fall-related conditions was associated positively with all six incident fracture sites. Falls are strongly associated with fractures (72), and a number of conditions predispose older Americans to falls, the most common of which in our analysis were history of overall body weakness and fatigue, stroke, senile and presenile organic psychotic conditions, Alzheimer's disease and previous accidental falls.

With regard to commonly analyzed demographic factors, our findings support those of other studies of fracture incidence among Medicare beneficiaries. For example, earlier studies of Medicare beneficiaries noted that hip fracture rates were highest in the South (25) or Southeast (28, 31, 73), that rates of hip, spine and nonhip/nonspine fractures were higher for whites than for blacks (8, 9, 22, 44) and that rates of most fractures were higher for women compared to men (4). Our finding of a higher incidence of clinical spine fractures in the South has not previously been reported, and it could represent true variation in fracture incidence or variation due to differences in detection.

Asian, African and Hispanic-Americans had lower incidence rates than white Americans for all fracture sites. Consistent with other studies (9), we found that African-Americans had the lowest rate of hip fracture. However, Asian-Americans had the lowest rate of ankle and tibia/fibula fracture, a finding not previously reported. Asian-American women have relatively low bone mineral density compared to white women (9, 74, 75) and women of other racial and ethnic groups (9, 74), and Asian descent is often listed as a risk factor for osteoporosis (76). However, studies examining hip fracture by race have found lower

fracture rates among Asian than white Americans (9, 33, 77). A reason hypothesized for the lower rate of hip fracture among Asian-Americans is a difference in hip geometry (74, 78, 79). This may not explain the lower fracture rates for other anatomic sites. Several studies have reported hip fracture incidence rates for Hispanic-Americans greater than for African-Americans but less than those for white Americans (9, 34). Our findings support those for hip, and we found this relationship to hold true for all other fracture sites examined. Lauderdale et al. (34) found marked differences in hip fracture rates among different Hispanic subpopulations, suggesting that considerable heterogeneity may be masked by our analysis of the Hispanic population in aggregate.

Our results for ankle fracture differed from those for other fracture sites, suggesting, as reported by others, that determinants of ankle fracture may differ from those of other fractures (8, 80), including foot fracture (81). Among our findings for ankle fracture are associations with history of fracture of the distal radius/ulna, other radius/ulna, humerus, femur and tibia/fibula. Others have reported a lack of association between bone mineral density and ankle fracture (80–82) and, consistent with our findings, no clear effect of age (81). The extent to which osteoporosis may contribute to ankle fracture remains unresolved and must be disentangled from the role of trauma, diabetes, overweight and obesity, and other health conditions.

Our results add to ongoing deliberations about which fractures may be considered osteoporosis-related (4). To the extent that observation of an increasing incidence of a fracture site with increasing age and a positive association with a history of prior fractures (especially those of the hip and spine) suggest that the fracture is attributable to osteoporosis, our results support an attribution to osteoporosis for fractures of the hip, spine, distal radius/ulna, humerus and tibia/fibula, but not for fracture of the ankle.

Our study has several strengths. Our large sample, including large numbers of racial and ethnic minorities, allowed us to evaluate fracture incidence for Hispanic and Asian-Americans, to examine the association between several chronic conditions, as well as a broad range of previous fractures, and specific incident fracture sites.

Use of Medicare claims data has inherent limitations (30, 83, 84). These include lack of information on medications, severity of the associated comorbidities, lifestyle factors, body composition of the patient and radiographic or clinical test results, as well as inaccuracies and inconsistencies in data coding by medical providers. Despite our efforts to address these limitations through the development of comprehensive algorithms for identification of fractures and through the use of diagnosis codes to identify people who potentially have comorbidities, some misclassification may remain, leading to the underestimation of associations. Misclassification of race and ethnicity in the Medicare claims data may have resulted in undercounting of minority populations, particularly self-reported Hispanic-Americans (85). Additionally, in interpreting the observed associations, the possible effect of multiple comparisons must be taken into consideration.

Because we did not have medication information, we used disease conditions for which glucocorticoids medications are prescribed as a proxy for actual use of these medications. This approach did not allow us to estimate the independent effects of these diseases and their treatments. The use of Medicare prescription drug data, available beginning in 2006, to examine these associations may be a useful direction for future research.

This study contributes to the understanding of patterns of osteoporosis-related fractures and of population groups at high risk for fracture, essential both to informing clinical practice and to targeting interventions. Targeted interventions addressing the risk of specific fractures should be developed for Americans of lower SES, those residing in the Southern

US, and those with histories of conditions pre-disposing them to falls, conditions for which glucocorticoid medications are prescribed, depression, diabetes, renal disease, cancer, and those having sustained previous fractures. Additionally, our results suggest that the definition of osteoporosis-related fractures be expanded to include fractures having incidence rates that increase with age and those associated with increased risk of subsequent fracture.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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APPENDIX

Table A

Other Medical Conditions: Categories and Codes

Condition Category	Code(s)
Glucocorticoid-related (summary indicator)	
Sarcoidosis	135
COPD, asthma	491, 492, 493, 494, 496
Rheumatoid arthritis	714
Polymyalgia rheumatica	725
Pemphigus	694.4, 694.5, 694.6
Systemic lupus erythematosus	710.0
Inflammatory myopathy	710.3, 710.4
Multiple sclerosis	340
Myasthenia gravis	358.0
Inflammatory bowel disease, Crohn's disease	555, 556
Wegener granulomatosis	446.4
Giant cell arteritis	446.5
Cushing's disease	255.0
Ankylosing spondylitis	720.0
Psoriasis	696.1
Psoriatic arthritis (Psoriatic arthropathy)	696.0
Reactive arthritis / Reiter's	099.3
Bone Disease-Related	
Paget's disease of bone	731.0
Hyperparathyroidism	252.0

Condition Category	Code(s)
Hyperthyroidism	242
Osteomalacia	268.2
Osteoporosis / Osteopenia	733.0, 733.90
Diabetes mellitus	250
Renal Disease	
Nephrotic syndrome	581
Other specified disorders resulting from impaired renal function	585, 586, 588.8
Other Bone Mass-Related	
Obesity	278.0
Ectopic hormone secretion	259.3
Tobacco addiction	305.1
Hypogonadism	257.2
Fall Related Conditions	
Stroke	430, 431, 432, 433, 434, 436
Transient ischemic attack (TIA)	435
Epilepsy	345
Convulsions	780.31, 780.39
Accidental falls	E880-E888
Senile and presenile organic psychotic conditions	290
Drug-induced dementia	292.82
Alzheimer's, Parkinson's, Huntington's (Neurological disorder, including all ICDs starting with substrings 331, 332 or 333)	331, 332, 333
General paresis	094.1
Dementia in conditions classified elsewhere	294.1
Disorders of the autonomic nervous system	337
Overall body weakness and fatigue	780.79
Cancer	140–<209 except 173, V10
Acute myocardial infarction	410, 412
Other heart conditions	398, 402, 404, 415, 425.4, 428, 429.4
Depressive illness	290.13, 290.21, 290.43, 292.84, 293.83, 295.70–295.75, 296.20–296.26, 296.30–296.36, 296.50–296.56, 296.60–296.66, 296.7, 296.80, 296.82, 296.89, 296.90, 296.99, 298.0, 300.4, 300.5, 301.10, 301.12, 301.13, 309.0, 309.1, 311

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Table 1

Baseline cohort characteristics; Medicare beneficiaries, 2000–2005

Variable	All Subjects (%)*	Women (%)	Men (%)
Total	1,694,051	988,922	705,129
Race/Ethnicity			
White	1,490,557 (88.0)	867,023 (87.7)	623,534(88.4)
Asian	21,608 (1.3)	12,465 (1.3)	9,143 (1.3)
African	131,440 (7.8)	80,783 (8.2)	50,657 (7.2)
Hispanic	25,225 (1.5)	14,400 (1.5)	10,825 (1.5)
Other	25,221 (1.5)	14,251 (1.4)	10,970 (1.6)
Age †			
65–69	639,503 (37.8)	343,952 (34.8)	295,551 (46.2)
70–74	361,026 (21.3)	201,936 (20.4)	159,090 (22.6)
75–79	304,933 (18.0)	180,446 (18.3)	124,487 (17.7)
80–84	206,052 (12.2)	130,681 (13.2)	75,371(10.7)
85+	182,537 (10.8)	131,907 (13.3)	50,630 (7.2)
Median (minimum, maximum)	72 (65, 131)	73 (65, 131)	71 (65, 131)
Calendar Year †			
2000	1,233,248 (72.8)	738,678 (74.7)	494,570 (70.1)
2001	85,950 (5.1)	46,430 (4.7)	39,520 (5.6)
2002	106,133 (6.3)	57,694 (5.8)	48,439 (6.9)
2003	101,505 (6.0)	54,759 (5.5)	46,746 (6.6)
2004	87,062 (5.1)	47,508 (4.8)	39,554 (5.6)
2005	80,153(4.7)	43,853 (4.4)	36,300 (5.2)
Urban/Rural			
1. Urban Core	1,076,509 (63.6)	636,779 (64.4)	439,730 (62.4)
2. Not Urban core	617,542 (36.5)	352,143 (35.6)	265,399 (37.6)
Geographic Region ‡			
1.Northeast	338,357 (20.0)	202,777 (20.1)	135,580 (19.2)
2.Midwest	441,418 (26.1)	258,251 (26.1)	183,167 (26.0)
3.West	270,733 (16.0)	151,663 (15.3)	119,070 (16.9)
4.South	643,543 (38.0)	376,231 (38.0)	267,312 (37.9)
Median Income §			
0–<30,000	358,851 (21.2)	218,293 (22.1)	140,558 (19.9)
30,000–<45,000	653,946 (38.6)	382,758 (38.7)	271,188 (38.5)
45,000–<60,000	362,136 (21.4)	208,973 (21.1)	153,163 (21.7)
60,000–<75,000	171,559 (10.1)	97,544 (9.9)	74,015 (10.5)
75,000+	143,916 (8.5)	79,482 (8.0)	64,434 (9.1)
Missing	3,643 (0.2)	1,872 (0.2)	1,771 (0.3)
Median (minimum, maximum)	$40,541 (2,499, 200,001)	$40,167 (0, 200,001)	$41,050.00 (0, 200,001)

* % = column percent.

† At start of follow-up.

‡ Four regions defined by the US Census Bureau.

§ Median household income for the census block group of residence for each beneficiary (based on 9-digit ZIP Code).

Table 2

Fracture incidence rate ratio[*] (and 95% confidence interval) for demographic variables, by type of fracture; Medicare beneficiaries, 2000–2005

Variable	Hip N[†]=1,672,183 PY[‡]=6,973,391 Fractures=60,354 IR[§]= 8.65/1,000	Spine N=1,675,419 PY=6,997,984 Fractures=44,120 IR= 6.30/1,000	Distal Radius/ Ulna N=1,684,791 PY=7,055,210 Fractures=24,347 IR= 3.45/1,000	Humerus N=1,684,720 PY=7,077,597 Fractures=19,393 IR= 2.74/1,000	Ankle N=1,686,668 PY=7,091,296 Fractures=13,454 IR= 1.90/1,000	Tibia/Fibula N=1,688,870 PY=7,119,730 Fractures= 6,385 IR= 0.90/1,000
Gender						
Female	1.00	1.00	1.00	1.00	1.00	1.00
Male	0.59 (0.58, 0.60)	0.58 (0.57, 0.60)	0.23 (0.23, 0.24)	0.38 (0.36, 0.39)	0.48 (0.46, 0.50)	0.49 (0.46, 0.52)
Race/ethnicity						
White	1.00	1.00	1.00	1.00	1.00	1.00
Asian	0.61 (0.56, 0.68)	0.8 (0.73 , 0.88)	0.63 (0.54, 0.74)	0.52 (0.43, 0.63)	0.37 (0.28, 0.49)	0.45 (0.31, 0.65)
African	0.46 (0.44, 0.48)	0.25 (0.24, 0.27)	0.32 (0.30, 0.35)	0.36 (0.33, 0.39)	0.67 (0.62, 0.72)	0.88 (0.79, 0.97)
Hispanic	0.68 (0.63, 0.74)	0.69 (0.63, 0.76)	0.90 (0.81, 1.01)	0.74 (0.64, 0.84)	0.74 (0.63, 0.88)	0.94 (0.76, 1.17)
Other	0.83 (0.77, 0.90)	0.74 (0.67, 0.81)	0.69 (0.60, 0.79)	0.72 (0.62, 0.84)	0.58 (0.48, 0.71)	0.81 (0.63, 1.04)
Age						
65–69	1.00	1.00	1.00	1.00	1.00	1.00
70–74	1.96 (1.87, 2.06)	1.72 (1.65, 1.80)	1.27 (1.21, 1.33)	1.43 (1.35, 1.52)	1.08 (1.02, 1.14)	1.19 (1.09, 1.30)
75–79	3.91 (3.74, 4.09)	2.80 (2.69, 2.92)	1.65 (1.58, 1.73)	2.06 (1.95, 2.18)	1.08 (1.02, 1.14)	1.44 (1.32, 1.56)
80–84	7.55 (7.22, 7.89)	4.24 (4.00, 4.42)	2.00 (1.91, 2.10)	2.70 (2.55, 2.86)	1.09 (1.03, 1.16)	1.64 (1.50, 1.79)
85+	15.16 (14.53, 15.83)	6.00 (5.76, 6.24)	2.34 (2.24, 2.45)	3.86 (3.65, 4.07)	1.19 (1.12, 1.26)	2.32 (2.13, 2.53)
Calendar Year						
2000	1.00	1.00	1.00	1.00	1.00	1.00
2001	0.97 (0.94, 0.99)	1.02 (0.99, 1.06)	0.98 (0.94, 1.02)	0.98 (0.93, 1.03)	0.95 (0.89, 1.01)	1.01 (0.93, 1.10)
2002	0.91 (0.89, 0.94)	1.04 (1.01, 1.08)	0.94 (0.90, 0.98)	0.97 (0.93, 1.02)	0.97 (0.91, 1.03)	0.97 (0.89, 1.06)
2003	0.91 (0.89, 0.94)	1.07 (1.04, 1.11)	1.01 (0.97, 1.06)	1.00 (0.95, 1.05)	1.02 (0.96, 1.08)	0.89 (0.81, 0.97)
2004	0.89 (0.87, 0.92)	1.11 (1.08, 1.15)	0.97 (0.93, 1.02)	0.97 (0.92, 1.01)	0.99 (0.94, 1.05)	0.97 (0.89, 1.06)
2005	0.86 (0.84, 0.89)	1.10 (1.06, 1.13)	0.95 (0.91, 1.00)	0.97 (0.92, 1.02)	1.01 (0.95, 1.07)	0.97 (0.89, 1.06)
Urban/Rural						
Urban Core	1.00	1.00	1.00	1.00	1.00	1.00
Not Urban core	0.99 (0.97, 1.01)	0.99 (0.97, 1.01)	0.93 (0.91, 0.96)	0.89 (0.86, 0.92)	0.99 (0.96, 1.03)	0.96 (0.91, 1.01)
Geographic region						
Northeast	1.00	1.00	1.00	1.00	1.00	1.00
Midwest	1.03 (1.01, 1.06)	1.11 (1.08, 1.14)	0.98 (0.94, 1.01)	0.90 (0.87, 0.94)	0.96 (0.92, 1.01)	0.98 (0.91, 1.05)
West	1.01 (0.98, 1.04)	1.14 (1.11, 1.18)	0.70 (0.67, 0.73)	0.72 (0.68, 0.76)	0.68 (0.64, 0.72)	0.72 (0.66, 0.79)
South	1.16 (1.13, 1.18)	1.22 (1.18, 1.25)	0.99 (0.96, 1.02)	0.94 (0.90, 0.97)	0.91 (0.87, 0.96)	0.91 (0.85, 0.98)
Median income						
0–<30,000	1.00	1.00	1.00	1.00	1.00	1.00
30,000–<45,000	0.94 (0.92, 0.96)	0.97 (0.95, 1.00)	0.99 (0.96, 1.03)	0.95 (0.92, 0.99)	1.00 (0.95, 1.04)	0.94 (0.88, 1.00)
45,000–<60,000	0.91 (0.89, 0.93)	0.94 (0.92, 0.97)	1.00 (0.96, 1.04)	0.94 (0.90, 0.99)	0.98 (0.92, 1.03)	0.88 (0.82, 0.95)
60,000–<75,000	0.88 (0.85, 0.91)	0.90 (0.87, 0.94)	0.93 (0.89, 0.98)	0.94 (0.89, 0.99)	0.93 (0.87, 1.00)	0.82 (0.74, 0.90)

Variable	Hip N[†]=1,672,183 PY[‡]=6,973,391 Fractures=60,354 IR[§]= 8.65/1,000	Spine N=1,675,419 PY=6,997,984 Fractures=44,120 IR= 6.30/1,000	Distal Radius/ Ulna N=1,684,791 PY=7,055,210 Fractures=24,347 IR= 3.45/1,000	Humerus N=1,684,720 PY=7,077,597 Fractures=19,393 IR= 2.74/1,000	Ankle N=1,686,668 PY=7,091,296 Fractures=13,454 IR= 1.90/1,000	Tibia/Fibula N=1,688,870 PY=7,119,730 Fractures= 6,385 IR= 0.90/1,000
75,000+	0.84 (0.81, 0.87)	0.89 (0.85, 0.93)	0.92 (0.87, 0.97)	0.86 (0.81, 0.92)	0.89 (0.82, 0.96)	0.82 (0.73, 0.91)

[*] Adjusted for all variables in this table.

[†] N, number of beneficiaries included in the analysis of each of the six incident fracture sites.

[‡] PY, person-years of follow-up.

[§] IR, crude incidence rate for the particular incident fracture site per 1,000 PY.

Table 3

Fracture incidence rate ratio* (and 95% confidence interval) for predisposing factors, by type of fracture; Medicare beneficiaries, 2000–2005

	Site of Incident Fracture					
Variable	**Hip**	**Spine**	**Distal Radius/Ulna**	**Humerus**	**Ankle**	**Tibia/Fibula**
PREVIOUS FRACTURI						
Distal Radius/Ulna	1.46 (1.39, 1.54)	1.37 (1.29, 1.45)	-†	1.74 (1.61, 1.88)	1.50 (1.34, 1.68)	1.44 (1.24, 1.67)
Other Radius/Ulna	1.21 (1.09, 1.35)	1.25 (1.11, 1.4)	1.29 (1.08, 1.55)	1.74 (1.48, 2.04)	1.56 (1.26, 1.94)	1.47 (1.11, 1.95)
Carpal Bones	1.08 (0.88, 1.34)	1.24 (1.00, 1.55)	1.92 (1.38, 2.67)	1.27 (0.93, 1.73)	0.88 (0.52, 1.48)	1.28 (0.74, 2.22)
Humerus	1.81 (1.72, 1.90)	1.75 (1.65, 1.86)	1.57 (1.44, 1.71)	-†	1.27 (1.11, 1.46)	1.75 (1.50, 2.04)
Clavicle	1.56 (1.36, 1.78)	1.99 (1.72, 2.30)	1.71 (1.37, 2.14)	2.16 (1.75, 2.67)	1.17 (0.79, 1.73)	1.71 (1.15, 2.54)
Spine, Closed	1.63 (1.56, 1.69)	-†	1.38 (1.28, 1.49)	1.58 (1.47, 1.70)	1.12 (0.99, 1.26)	1.58 (1.38, 1.81)
Spine, Other	1.17 (1.05, 1.30)	-†	0.91 (0.73, 1.14)	1.26 (1.04, 1.51)	0.95 (0.67, 1.35)	1.11 (0.76, 1.61)
Pelvis	1.59 (1.49, 1.69)	1.87 (1.74, 2.01)	1.30 (1.15, 1.46)	1.40 (1.25, 1.58)	1.19 (0.98, 1.43)	1.63 (1.35, 1.97)
Hip	-†	1.48 (1.42, 1.54)	1.33 (1.25, 1.41)	1.49 (1.40, 1.58)	0.86 (0.77, 0.95)	1.75 (1.58, 1.93)
Femur	1.31 (1.17, 1.47)	1.23 (1.10, 1.38)	1.15 (0.98, 1.36)	1.12 (0.94, 1.34)	1.73 (1.40, 2.13)	4.37 (3.70, 5.15)
Tibia/Fibula	1.33 (1.19, 1.47)	1.25 (1.11, 1.42)	1.32 (1.11, 1.56)	1.20 (0.99, 1.46)	1.70 (1.35, 2.14)	-†
Ankle	0.99 (0.91, 1.08)	1.14 (1.04, 1.25)	1.27 (1.12, 1.43)	0.96 (0.82, 1.11)	-†	2.60 (2.19, 3.09)
OTHER PREDISPOSING CONDITIONS‡						
Glucocorticoid-related	1.20 (1.18, 1.22)	1.47 (1.44, 1.50)	1.09 (1.06, 1.12)	1.16 (1.13, 1.20)	1.05 (1.02, 1.09)	1.15 (1.09, 1.21)
Diabetes	1.01 (0.99, 1.02)	0.98 (0.96, 1.00)	0.95 (0.93, 0.98)	1.22 (1.18, 1.26)	1.35 (1.30, 1.39)	1.15 (1.09, 1.21)
Fall-Related	1.70 (1.67, 1.74)	1.53 (1.50, 1.57)	1.24 (1.20, 1.27)	1.43 (1.38, 1.48)	1.27 (1.22, 1.32)	1.39 (1.31, 1.47)
Renal Disease	1.20 (1.17, 1.23)	1.05 (1.02, 1.08)	1.00 (0.96, 1.05)	1.11 (1.06, 1.16)	1.09 (1.02, 1.15)	1.18 (1.09, 1.27)
Depressive Illness	1.45 (1.43, 1.48)	1.25 (1.22, 1.28)	1.23 (1.20, 1.27)	1.27 (1.23, 1.32)	1.25 (1.20, 1.30)	1.33 (1.25, 1.40)
AMI	1.06 (1.04, 1.09)	1.03 (1.00, 1.06)	1.01 (0.97, 1.06)	1.05 (1.00, 1.10)	1.02 (0.96, 1.08)	1.00 (0.92, 1.09)
Other Heart Disease	1.10 (1.08, 1.12)	1.18 (1.15, 1.20)	0.98 (0.95, 1.00)	1.06 (1.03, 1.10)	1.09 (1.05, 1.13)	1.12 (1.06, 1.18)
Bone Disease	1.01 (0.98, 1.05)	1.12 (1.07, 1.16)	1.07 (1.01, 1.13)	1.00 (0.94, 1.07)	1.02 (0.94, 1.10)	1.04 (0.93, 1.16)
Cancer	1.08 (1.07, 1.10)	1.22 (1.20, 1.25)	1.05 (1.02, 1.08)	1.12 (1.09, 1.16)	1.05 (1.01, 1.09)	1.03 (0.98, 1.09)

*Rate ratios for each variable are adjusted for all other variables included in Tables 2 and 3.

†Rate ratio not computed: by design, the cohort for each incident fracture site excluded beneficiaries with a history of that fracture site.

‡Conditions included in each category, with accompanying ICD-9 codes, are listed in the Appendix.